INITIAL STUDY OF
MANUFACTURED GAS PLANT SITE
CORNWALL, ONTARIO

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Waste Management Branch

Report prepared by:
Golder Associates (Eastern Canada) Ltd.

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SUMMARY

This report presents the results of an initial study of the former manufactured gas plant site in Cornwall, Ontario which operated between 1882 and 1929. The purpose of this study was to determine if coal gasification plant wastes are present on-site and, if so, to assess their present and/or potential future environmental impact.

Phase I of the study involved the examination of available historical documentation to assess the potential for wastes to be present on the site, together with a shallow boring program to enable a soil gas survey for volatile organic compounds to be carried out. During Phase I an oily product recovered from a borehole located within the area of the former gas holder was identified by a laboratory characterization scan to contain polynuclear aromatic hydrocarbons (PAH) typical of coal tar.

Phase II of the study consisted of a borehole program in the area of the former gas holder. An apparently localized area of fill material exists to about 3.5 metre depth within the surrounding native silty clay soil; boreholes which encountered this deeper fill also encountered a free oily product which was subsequently confirmed as coal tar containing elevated levels of PAH. PAH were also detected in native clay and glacial till soil samples where no free product was observed, but at significantly lower concentrations. The on-site groundwater in the area downgradient of this fill material is contaminated with PAH and BTEX compounds (benzene, toluene, ethylbenzene, xylenes).

SUMMARY (CONT'D)

The presence of coal tar product and groundwater contamination within a few metres of the south property line suggests that there is potential for off-site contaminant migration to have occurred. Fill materials associated with buried service lines off-site beneath Water Street are indicated to be a likely receptor. Additional investigation to determine the impact, if any, on these services should be undertaken.

In view of the relative isolation of the buried wastes beneath the parking lot, i.e. there is no direct exposure to the wastes or waste impacted materials, there does not appear to be adverse impacts on human or environmental health and safety at the present time. However, if construction projects are undertaken near the location of the wastes precautions should be taken to avoid potential exposure of personnel to the wastes.

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1.0 INTRODUCTION

Golder Associates was retained by the Ontario Ministry of the Environment (MOE) to conduct an initial study of a former manufactured gas plant site in Cornwall. The site is located at the corner of Amelia Street and Water Street in Cornwall (see Figure 1). This report presents the details and findings of the initial investigations undertaken at the Cornwall manufactured gas plant site.

1.1 Purpose of Study

This initial study was undertaken after a recent inventory of coal gasification plant sites in Ontario revealed a total of 41 municipal gas plant sites. Of these 41 sites, coal tar waste had been found at several sites and remediation was underway; of the remaining sites little or nothing was known about the presence of coal tar wastes.

During the inventory of plant sites, the Cornwall site had been classified as a low priority site, since the site was not considered likely to present an impact on the environment.

The purpose of the initial study of the Cornwall gas plant site is as follows:

1) to determine whether or not coal gasification plant wastes are present;

2) if present, to determine how these wastes occur on the site (in storage tanks, in soil, etc.) and obtain some indication of their distribution;

3) if present, determine whether the wastes are contained, or whether the wastes, or contaminated water, or both may be moving off-site;

4) if present, determine whether or not the wastes are impacting on or pose an immediate threat of impact on human health and safety, or the environment or both

5) if present, determine whether coal tar contamination or contaminated groundwater could seep into the two residences located on the site.

To achieve the objectives of the study, the work was carried out in two phases. In Phase I a search to assess the potential presence of waste materials based on a review of available site data and shallow boreholes was carried out. In Phase II a detailed borehole drilling and monitoring well installation program was carried out. The details of each phase of the study are presented later in this report.

1.2 Manufactured Gas Plant Works

Most of the information presented in this section is derived from the "Handbook on Manufactured Gas Plant Sites" by Environmental Research and Technology Inc. and Koppers Company Inc., published in 1984 (ERT and Koppers, 1984).

During the latter half of the nineteenth century and the first half of the twentieth century, gas fuel was manufactured from coal and oil and was widely distributed to residential, commercial and industrial users.

In the east part of the United States and Canada, most of the manufactured gas was generated from coal by several different methods. The most common form of manufactured gas was blue gas (sometimes called water gas) and was produced by reacting coal or coke with steam to generate a gas rich in hydrogen and carbon monoxide. Usually this gas was enriched by adding petroleum oils to the hot gas

and cracking the oil by carburetion. The resultant gas was known as carberetted water gas or, more commonly, water gas. Another common method of gas production involved the carbonization of coal.

On the west coast of the United States, most of the manufactured gas was generated by oil by a variety of processes which cracked the oil into a gaseous product known as oil gas. The use of oil gas plants gradually spread to the eastern U.S. and in later years many water gas plants were converted to oil gas plants. Oil gas plants used a variety of feedstocks ranging from kerosene or diesel oil up to heavy Bunker C fuel oil.

A historical review of the Cornwall gas plant has shown that initially the plant was operated as a coal carbonization or water gas plant from 1883 to sometime between 1885 and 1890. At some time between 1885 and 1890 the plant was converted to an oil gas plant.

Associated with the operation of manufactured gas plants was the production of numerous wastes. The major waste products from the operation of gas plants included: tars, sludges, tar liquor and ammonia liquor, spent iron oxide, ash, slag, clinkers, dust, off-grade coal and coke. Detailed descriptions of the waste products associated with the operation of coal carbonization, water gas and oil gas plants can be found in Appendix A. Of the wastes produced by manufactured gas plants, the ones of main concern with respect to environmental impact are tar sludge, oxide box wastes and ash.

Tar sludges contain polynuclear aromatic hydrocarbons (PAH), phenolics and light aromatic hydrocarbons (BTEX). Prior to 1900 these tars were disposed as a waste product,

however, they were later stored and then commercially refined into various tar distillation products.

Our understanding of the geochemistry and mobility of coal tar and its derivatives indicates that two separate phases of contaminant may develop in areas of coal tar release. The coal tar fluid phase behaves as an immiscible denser than water phase which may migrate downward under the influence of gravity, until it reaches a surface that impedes its further downward migration; lateral spreading of a pool of product can then occur. A separate dissolved aqueous phase solution (leachate) will migrate with the groundwater flow regime, although the rate of contaminant migration may be less than the actual groundwater flow velocity due to mechanical and chemical processes which retard the migration and which depend largely on the nature of the porous media and of the dissolved chemical constituents.

The chemical constituents of coal tar of greatest concern from the environmental impact/health and safety point of view are PAH. These compounds are generally very stable and persistent in the environment and exhibit generally high adsorption, low volatility and aqueous solubility. Napthalene, which is relatively biodegradable, is the most volatile and soluble of the group of compounds and is relatively mobile in groundwater flow systems when compared to the other compounds. Benzo(a)pyrene (B(a)P) exhibits very low solubility and is strongly adsorbed on carbon compounds, but remains the constituent of primary concern to regulatory agencies due to its suspected carcinogenic properties.

The phenolic compounds occur in very small concentrations in water gas tars and higher concentrations in coal gas tars. They are highly soluble in water and have little tendency to volatilize or adsorb, however, they are readily biodegradable. The light aromatics are primarily benzenes, toluene and xylenes which are moderately soluble and will travel with groundwater with minor attenuation by adsorption.

Oxide box wastes consist of various salts which are high in sulphur, cyanide and ammonium and often have a blue colour associated with ferrocyanide. These compounds are understood to be relatively stable in a neutral pH environment, however, they may be leached into groundwater.

Ash can contain trace metals associated with the coal including arsenic, copper, chromium, iron, lead, nickel and zinc. Once leached from the ash, the mobility of the metals in groundwater is often retarded by adsorption/ precipitation reactions with the soils.

2.0 PHASE I INVESTIGATION

Phase I of the study consisted of a review of historical records and historical aerial photographs, collection and examination of subsurface data from previous geotechnical investigations in the area as well as published geological maps and reports, and a limited borehole drilling program.

2.1 Previous Geotechnical Investigations and General Subsurface Conditions

Borehole logs from previous geotechnical investigations in the area were obtained and reviewed. These investigations were carried out for the installation of storm and sanitary sewers along Water Street, the foundation design for the Parks Canada Building and the foundation design for the proposed seniors building at the corner of Amelia Street and First Street. Copies of the borehole logs from these investigations can be found in Appendix B. The location of the borehole is shown on Figure 2. Based on these borehole logs four soils profiles were prepared (Figures 3, 4 and 5) to illustrate the subsurface conditions in the study area.

Cornwall lies within the physiographic region known as the Glengarry till plain which is characterized by extensive glacial till ridges and drumlins in rolling terrain, sometimes interrupted by marine clay flats. The upper bedrock in much of the Cornwall area consists of shales and sandstones of the Rockcliffe and St. Martin Formations; adjacent to the St. Lawrence River the underlying Oxford Formation dolomite is indicated to comprise the upper bedrock.

As shown on Figures 2 to 5, considerable subsurface data exists in the specific area surrounding the former Gas Plant site. Following is a summary of the general subsurface conditions in the area of the site.

Fill materials, associated with former activities, uses and/or topography in this area, generally overly the native soils. In the vicinity of Amelia Street and First Street to the north, about 1.5 to 5 metres of miscellaneous fill associated with the infilling of a former creek exists. Along and to the south of Water Street, extensive silty earth fill deposits used to infill the former Cornwall Canal in the early 1960's extend to depths of about 6 to 7 metres.

To the north of Water Street, the fills are underlain by an extensive deposit of sensitive marine silty clay. The thickness of the silty clay soils is indicated to generally decrease in a north to south direction, from about 10 metres north of the Gas Plant site to about 4 to 5 metres along Water Street; south of Water Street the clay was excavated over 140 years ago for the canal construction. The upper 3 to 4 metres of the clay deposit are indicated to have been weathered to a very stiff crust which, because of dessication, has a typically fissured structure. The lower portion of the clay is grey in colour and has a generally firm to stiff consistency; although no Atterberg limit data are available, natural moisture content values of 60 to 70 percent suggest an in situ water content which is at or in excess of the liquid limit as is typical of sensitive marine clays.

Underlying the clay, an extensive layer of glacial till exists. The till typically consists of a sandy silt matrix with some gravel and a trace to some clay (about 50 to 60 percent silt and clay sizes, 10 to 20 percent clay

sizes), as well as cobbles and boulders. Significant variation in material composition can exist within the till sheet due to reworking/washing/glacial tectonic action, however, such features were not noted in the boreholes. The silty glacial till is generally in a dense state of packing.

The glacial till extends to bedrock. In the vicinity of First and Amelia Streets, bedrock described as sandstone with shaley beds was encountered at 21.5 metres depth (about elevation 33 metres, Geodetic). Beneath the Civic Complex to the south, dolomite bedrock was encountered at about 20 metres depth (elevation 31.4 metres).

Extrapolating from this data to the Gas Plant site suggests that fill materials likely overly clay soils to about 6 to 7 metres depth, followed by some 12 to 15 metres of glacial till and then bedrock.

Groundwater level data from the previous investigations is limited, however, the water table is generally of the order of 1 to 3 metres deep in natural soils and about 4 to 5.5 metres along Water Street east of Amelia Street where it is likely influenced by sewers or the former canal. Groundwater elevations decline from north to south towards the St. Lawrence River.

2.2 Historical Records

Copies of historical aerial photographs of the Cornwall area taken in 1929, 1958, 1972 and 1983 were obtained from the National Air Photo Library in Ottawa and reviewed. A copy of the 1916 Fire Insurance Plan for the area was obtained from Public Archives Canada, also in Ottawa. Enlargements of the area of the gas plant site from the

1929, 1958 and 1983 aerial photographs and the 1916 Fire Insurance Plan are shown on Figure 6.

In the 1929 air photo, the buildings shown on the 1916 Fire Insurance Plan are still standing, but there are no indications of an above ground gas holder. By the time that the 1958 air photo was taken, all of the buildings associated with the gas plant site had been razed and the existing structures found at the site today were in place. Of interest are the building just to the east of the former gas holder location and the storage shed located to the north of the former gas holder location. The storage shed and building, which were still standing in 1972, were operated for a number of years by Gauthier Welding Supplies. According to City of Cornwall Public Works employees (Fielding and Flaro, personal communication 1988), these buildings were razed in 1973 or 1974. When the large basementless building was torn down, all of the building foundations were removed and taken from the site and the resulting excavation was infilled before paving the area for a parking lot. The 1983 air photo shows the site as it exists today.

A review of a history of the Cornwall Street Railway Light and Power Company (Carter-Edwards, 1987) showed that in July 1882, the town councillors passed a bylaw authorizing the laying of gas mains along the streets of Cornwall and that the Cornwall Gas Works was incorporated by provincial charter on August 1, 1882. The first recorded use of gas in the Town of Cornwall was on June 8, 1883 when a gas light was turned on in front of the town hall, and by the end of 1883 gas lighting had appeared along many of the streets where mains had been laid.

In March 1885, the gas works company had to borrow money to pay the mortgage on the company's property and to improve the existing facilities. The money raised by the issuing of bonds was used to introduce the manufacturing of gas from petroleum sources rather than coal sources. An article in the Cornwall Freeholder dated August 15, 1890 described the process.

In 1890, the Cornwall Gas Works defaulted on payment of the bonds taken out in 1885 and the plant was taken over by the bondholders who ran the plant until 1892 when clear title to the plant was obtained by four individuals who were also associated with the Stormont Electric Company. In December 1893, control of the gas plant was passed to the Stormont Electric Company and was later obtained by the Cornwall Street Railway, Light and Power Company who operated the plant until its closing in 1929.

The gas plant was closed in 1929 after the gas holder on site collapsed. Because there were so few users of gas in the town at that time, the operators of the plant deemed it to be more economical to pay for the users to convert to other forms of fuel rather than to repair and rebuild the gas holder (Carter-Edwards, personal communication, 1988).

Old newspaper articles, town council minutes and other sources comment on dumping of wastes from the gas plant into the old Cornwall Canal, however, the nature of the wastes is not described. There are no records indicating that wastes were removed from the site for refining or disposal elsewhere (Carter-Edwards, personal communication, 1988).

2.3 Borehole Drilling

During the Phase I investigation six shallow boreholes and one deeper borehole were drilled on the site on March 22, 1988 at the locations shown on Figure 7. The shallow boreholes (numbered I-1 to I-6) were drilled to depths ranging from 0.40 to 0.76 metre. All of the shallow boreholes were advanced into native clay below sand and gravel fill. The deeper borehole I-7 was located in the centre of a slightly depressed area bounded by a circular crack in the asphalt pavement. This area is approximately 12 metres in diameter and is believed to be the location of the former coal gas plant gas holder. The boreholes were drilled using an electric portable drill supplied by Wilf Ohlmann Geotechnical Services of Ottawa.

Prior to commencing drilling operations on the site, air quality measurements were made using a Photovac TIP II photo ionizing detector (PID) to measure total volatile organic compounds (VOC). The TIP II was first calibrated to a standard of 100 ppm isobutylene and was then zeroed in a clean air zone. Measurements were then made at several locations around the site to determine background VOC readings. During the drilling of the boreholes, air quality measurements were made in the working zone around the top of the borehole, in the normal standing breathing zone on a continuous basis and at the monitoring stations around the site at intervals of 15 minutes. The location of the air quality monitoring stations are shown on Figure 8. At no time during the drilling operations did the VOC readings on the site exceed the background conditions.

After each borehole was drilled, the mouth of the borehole was sealed with a disposable latex rubber surgical glove and the sampling tube of the TIP II was inserted and left

in the hole for a period of 5 minutes to obtain a reading of VOC in the borehole.

A description of the subsurface conditions encountered in the Phase I boreholes can be found in Appendix C, Part 1.

2.4 Results of Phase I

In each of the shallow boreholes, asphalt overlying a sand and gravel fill was encountered to depths ranging between 0.4 and 0.6 metre. This pavement structure overlies clayey soil, either fill or native material. In boreholes I-1, I-2, I-3 and I-4, a layer of cinders approximately 1 centimetre thick was observed at the contact between the sand and gravel fill and the brown clay soil.

In borehole I-7, fill materials were present from surface to the final depth of about 2 metres where an oily material was encountered. The upper 0.6 metre of fill was primarily sand and gravel materials. Between 0.6 and 1.1 metres, the fill consisted of a clay that had dark staining. This material also gave a reading of 8 ppm on the TIP II. Between 1.1 and 2.0 metres the fill was composed of sand and gravel, brick fragments and cinders.

During the drilling, TIP II readings above the background level of 0 ppm were noted only in boreholes I-4 and I-7. In borehole I-4, the TIP II reading on completion of the borehole was 58 ppm. It is believed that this reading was associated with a black cinder-like material that had a TIP II reading of 51 ppm. In borehole I-7 the TIP II reading on completion of the borehole was 16 ppm and is probably associated with a black, tarry, oily material that was coating sand and gravel in a sample obtained from between 1.7 and 2.0 metres below ground.

It should be noted that the Phase I drilling was carried out on March 22, 1988 and that the ambient air temperature was approximately 3 degrees Celsius. The relatively low ambient temperature may have resulted in TIP II readings that would be lower than readings obtained under warmer conditions in thawed ground that could increase volatilization from a borehole opening.

As previously mentioned, a black tarry, oily substance was found in sand and gravel fill between 1.7 and 2.0 metres below ground in borehole I-7. A sample of this material was submitted to ZENON Environmental Inc. (ZENON) in Burlington, Ontario for a gas chromatography/mass spectrometry (GC/MS) characterization. The GC/MS characterization detected 25 compounds that are all polynuclear aromatic hydrocarbons (PAH). The range and relative concentrations of the PAH are similar to those expected in coal tar samples and it was concluded that coal tar wastes were present at the site. The results of the GC/MS characterization analyses and a brief letter report from ZENON regarding these analyses can be found in Appendix D, Part 1.

Based on the results of the field work carried out in Phase I and the chemical analyses performed, the following conclusions were made.

1) Coal tar wastes are present at the site in borehole I-7 which coincides with the location of the former gas holder.

2) No evidence of coal tar wastes was observed or indicated by TIP II readings in the shallow boreholes except possibly I-4 where a black oily stain was observed.

3) Additional work would be required to define the vertical and areal extent of the coal tar wastes, in order to fulfill the objectives of this initial study.

The additional work was undertaken as Phase II of this investigation which is described in the following sections of this report.

3.0 PHASE II INVESTIGATION

Based on the findings of the Phase I investigation and discussions with MOE, it was decided to drill additional boreholes in the area of borehole I-7 to attempt to define the on-site extent of coal tar product in the ground. Monitoring wells were to be installed to obtain groundwater samples to determine any impact of the former site use on the groundwater regime.

3.1 Borehole Drilling

A total of 5 boreholes, numbered II-1 to II-5, were drilled in and around the area defined by the circular crack in the Water Street Arena parking lot (Figure 9). The boreholes were drilled on May 4 and 5, 1988 using track mounted power auger drilling equipment operated by Marathon Drilling Ltd. of Ottawa. The boreholes were advanced using a 7.62 centimetres diameter continuous sampler inside 8.26 centimetres ID hollow stem augers. The continuous sampler is a 1.52 metres long barrel which is held stationary relative to the rotation of the augers and is advanced with the augers.

Prior to drilling at each location, heavy polyethylene sheeting was placed under the rear of the drill to facilitate containment of the cuttings. The cuttings were later placed in steel drums for disposal at the Stablex waste landfill.

After each drilling run with the continuous sampler, the sampler was pulled from the hole. A TIP II PID was used to determine the presence of any VOC prior to opening the sampler. When the sampler was opened, the TIP II was used to assess the sample to determine VOC levels.

The samples were then logged in detail and representative samples were retained for future reference and chemical testing. The remaining portion of the sample was placed in disposal drums.

The boreholes were advanced to a total depth of 5.6 to 6.4 metres. Upon completion, monitoring wells were installed in 3 of the 5 boreholes, while the remaining 2 boreholes were sealed to surface with bentonite pellets and some cuttings. Details of the subsurface conditions encountered during drilling and the monitoring well installations can be found on the Record of Borehole sheets in Appendix C, Part 2.

After the drilling operations had been completed all cuttings, plastic sheeting, gloves, coveralls, etc. were placed in disposal drums for transport to an off-site disposal area. The drill was cleaned with a high pressure, low volume hot water cleaner at a location designated by MOE and City of Cornwall personnel. The parking lot area was swept and washed to remove any materials left on surface as a result of the drilling operations.

During the drilling operations and monitoring well installations, air quality measurements were made at the mouth of the borehole, in the working breathing zone, normal breathing zone on a continuous basis and at several stations around the site at intervals of 15 minutes (Figure 8) with a TIP II PID. Prior to drilling the TIP II was calibrated with a 100 ppm isobutylene gas and was used to determine background conditions which were 0 ppm. Throughout the drilling the air quality around the site at the perimeter monitoring stations did not exceed background levels. The only elevated readings were obtained at the mouth of the boreholes.

During the drilling operations the health and safety plan described in Appendix E was in place to protect the on-site personnel. In addition to this health and safety plan, access to the parking lot was restricted to the authorized on-site personnel.

3.2 Monitoring Well Installations

Monitoring wells were installed in boreholes II-I, II-2 and II-3 to enable collection of groundwater samples and to measure groundwater levels. The monitoring wells were constructed from 3.81 centimetre diameter, schedule 40, flush threaded joint PVC materials. The well screens were 1.52 metres in length and consist of machine slotted PVC pipe with a #10 slot size. The well screens were placed in the bottom of the borehole, and a sand pack was placed to a minimum depth of 0.6 metres above the top of the screen. A bentonite pellet seal was placed over the sand pack and the remaining borehole annulus was backfilled with clay cuttings to a depth of 1 metre below ground surface. A protective surface casing fabricated from 10 centimetres diameter ABS pipe fitted with a flush mount valve box was set over the monitoring well and the annular spaces were backfilled to 15 centimetres below ground surface with bentonite pellets. Gravel was placed to a depth of 3 centimetres below ground surface and a cold mix asphalt compound was placed at the top of the borehole to seal the annulus.

After installation the monitoring wells were developed and were allowed to stabilize for approximately 3 weeks at which time they were purged and sampled (see Section 3.4).

3.3 Surveying

All of the Phase II boreholes and monitoring wells were surveyed for elevation and were horizontally tied into existing buildings by Golder Associates. The elevations were surveyed with reference to a City of Cornwall bench mark located on the Lally-Blanchard building on the south side of Water Street across from the Water Street Arena. The bench mark elevation was supplied to us as 54.593 metres, Geodetic datum.

3.4 Sampling

3.4.1 Groundwater

Groundwater samples were collected from the monitoring wells at the site on May 25, 1988. Prior to collecting the sample, a minimum of three standing well volumes were bailed from the well using a stainless steel bailer. The samples were then collected, filtered and preserved as necessary and were placed in coolers with ice packs for transporting to the laboratory. The bailer was cleaned between boreholes by a series of distilled water/methanol rinses. All analyses were carried out by ZENON Environmental Inc. of Burlington. Analyses were carried out for the following parameters: pH, COD, TOC, total phenolics, total cyanide, ammonia, TKN, sulphide, anion scan by IC methods, cation/metal scan by ICAP methods, BTEX and PAH.

3.4.2 Soil

Soil samples collected during the borehole drilling were placed in clear glass jars with foil lined caps and were shipped in coolers with ice packs to ZENON Environmental Inc. for analyses. Because coal tar wastes had been located during the Phase I investigation, the Phase II soil samples were submitted for a GC/MS characterization of coal tar wastes. This characterization analyzes a suite of 18 PAH parameters that are typically found in coal tar wastes. In addition to these analyses, several soil samples which were not obviously contaminated were submitted for analyses by an acetic acid leach test of the soil with the resultant leachate being analyzed for arsenic, anions by IC scan and cations by ICAP scan, in order to classify the soils as hazardous or non-hazardous under Ontario Regulation 309. In addition a GC/MS scan for coal tar parameters was carried out on four of the soil leachates to determine if the type and concentrations of PAH, in particular B(a)P, would result in the soils being classified as hazardous with respect to off-site disposal of the soils. The results of the analyses are presented in Table 6.

4.0 HYDROGEOLOGIC CONDITIONS

This section of the report summarizes the conditions encountered in the Phase II boreholes, located within the present parking lot in the area of the former gas holder on the Gas Plant site. For details at a particular borehole location, reference should be made to the individual Record of Borehole sheet. The subsurface conditions are also illustrated on the soil profiles on Figure 10.

4.1 Overburden Materials

The parking lot pavement structure consists of a thin layer of asphalt followed by brown sandy subbase fill to a depth varying from about 0.35 to 1.3 metres.

In boreholes II-3 and II-5, fill materials extend to a depth of about 3.7 metres below present ground surface. These fills consist of a mixture of earth and rubble fill (brown silty clay with sand, brick, gravel, cinders, concrete, traces of organic matter). In the lower 0.3 metres of the fill in boreholes II-3 and II-5 (about 3 to 3.5 metre depth) a mixture of organic material and fill was encountered, and was observed to contain a free oily product; in Phase I borehole I-7, the oily product was encountered at a shallower depth of about 1.7 metres.

Below the surface fill in the remaining boreholes II-1, II-2 and II-4, native silty clay soils were encountered; native silty clay soils also underlie the thicker fills in boreholes II-3 and II-5. To a depth of about 4 to 4.5 metres below the present ground surface, the clay has been weathered to form a very stiff brown crust; some weathering of the clay below the deeper fill was also

evidenced by its grey brown colour. The underlying part of the silty clay is grey in colour, has a stiff consistency, and a relatively highly plastic texture. The silty clay soils extend to some 5.2 to 6 metres below present ground surface.

Beneath the silty clay the borings encountered and were terminated in the upper part of the sandy silt glacial till deposit.

These subsurface conditions, in terms of both subsurface materials and strata thicknesses, are in good agreement with the general trends indicated by the historical data collected during Phase I of the study.

4.2 Physical Hydrogeology

The groundwater levels measured on May 25, 1988 in monitoring wells installed within the silty clay were at about 2 to 3.4 metre depth. As illustrated on Figure 11, the corresponding on-site groundwater elevations indicate a general flow direction at the site which is southward towards the St. Lawrence River. This is in agreement with the available data from previous investigations. The estimated horizontal hydraulic gradient across this part of the site is 0.10. This high horizontal gradient may reflect the influence of a general lowering of the water table along Water Street due to service installations and drainage along service pipe bedding. Based on previous investigations carried out for the construction of the Cornwall Civic Complex, the groundwater table south of Water Street was very flat with a horizontal gradient of less than 0.001. The groundwater levels south of Water Street at the time of investigation in 1974 reflected the elevation of the St. Lawrence River. Some localized

recharge may also be occurring through the sand cap which is indicated to overlie the clay soils in the elevated ground to the northeast of the parking lot and north of the arena.

In terms of hydraulic conductivity (K) characteristics, the weathered silty clay which is dessicated and fissured generally exhibits K values which are one to three orders of magnitude higher than the underlying grey silty clay. Although site specific hydraulic conductivity testing was not carried out, horizontal K values in the weathered clay crust are typically about $1x10^{-5}$ centimetres per second, and in the unweathered grey clay about $1x10^{-7}$ to $1x10^{-9}$ centimetres per second based on our local experience. Typical K values for the silty glacial till matrix are of the order of $1x10^{-6}$ centimetres per second. As such, the native soils are indicated to be of relatively low permeability, with the potential for highest groundwater velocities via interconnected fissures in the upper weathered "active" zone in the clay. The fill materials are expected to have a generally higher K than the native soils, with the direction and rate of groundwater flow off-site depending on the gradation, location and interconnection of fills existing on and adjacent to the property.

5.0 RESULTS OF CHEMICAL ANALYSES

The results of the chemical analyses carried out on the groundwater and soil samples collected during Phase II are presented in Tables 2, 3, 5, 6 and 7. Complete details regarding the methodology for the PAH and BTEX analyses are presented in Appendix D, Part 2.

The quality control checks by surrogate recovery indicate that the analyses are representative. A quality control check on sampling and cleaning procedures by means of a bailer blank indicate that the cleaning methods used were satisfactory.

5.1 Groundwater Samples

The results of the chemical analyses on the groundwater samples are presented in Tables 2, 3 and 4.

During the collection of the groundwater samples, the sample from MW#3 exhibited three separate phases of PAH. Present were a floating light non-aqueous phase liquid (LNAPL), a sinking dense non-aqueous phase liquid (DNAPL) and a dissolved phase. The apparent LNAPL phase may represent either an emulsified mixture of DNAPL and aqueous phases, or an actual light oil phase.

The results of the chemical analyses (Table 3) show that PAH were present in all 3 groundwater samples. The sample from MW#3 which is located downgradient from the former gas holder location and in a borehole where free product was observed had the highest total PAH concentration (32,095 µg/l) including 450 µg/l of B(a)P. The analyses of the groundwater samples containing coal tar liquids do not necessarily mean that the high concentrations are

in fact dissolved in the groundwater. PAH typically have low solubilities in water. The high concentrations may be the result of a small blob of PAH being present in the portion of the sample analyzed. The distribution of the total PAH concentration in the groundwater is shown on Figure 12. The concentrations of BTEX in the groundwater (Table 4 and Figure 13) show that the concentrations are highest in MW#3 which was installed in borehole II-3. In the other monitoring wells, BTEX was not detected at the minimum detection limits i.e. migration of BTEX in groundwater appears to be essentially downgradient rather than cross gradient.

5.2 Soil Samples

The results of the chemical analyses on the soil samples are presented in Tables 5, 6 and 7. Complete details regarding the methodology of the PAH analyses can be found in Appendix D, Part 2.

The results of cation and anion scans performed on acetic acid leachate (Table 5) indicate that the soils are non-hazardous under Ontario Regulation 309 in terms of inorganic parameters. Ontario Regulation 309 uses a criteria of 100 times the Ontario Drinking Water Objective for given parameters in the leachate to determine if wastes are hazardous or non-hazardous. The Ontario Drinking Water Objectives are presented in Table 8.

The results of the PAH analyses (Table 7) show that measurable levels of PAH were found in soil samples in all Phase II boreholes. The highest PAH levels were found in boreholes II-3 and II-5 where a free oily product was found. The results of the analyses confirm that the oily product is a coal tar waste material.

Regulation 309 defines coal tar (the oily tar itself) as a hazardous waste. If coal tar is obviously present in a soil sample, then the soil sample is classified as a hazardous waste. The classification as hazardous or non-hazardous for soils which do not obviously contain coal tar is based on the results of a Regulation 309 leach test followed by analysis for B(a)P; the current limit for B(a)P from this test is 1 ppb. In the 4 samples tested B(a)P was not detected at the minimum detection limit of 0.01 µg/l (ppb).

The vertical distribution of total PAH in the soils is shown on Figure 14. As expected the highest total PAH concentrations are in fill and are associated with the presence of free coal tar product in boreholes II-3 and II-5. In borehole II-5, the total PAH concentration decreases with depth, but there is still a total PAH concentration of 31.7 µg/g in the native silty clay at a depth of 5.64 metres (compared to the total PAH concentration of 859 µg/g in oily fill at a depth of 3.35 metres). This indicates that there has been downward migration of PAH through the fill to at least the depths of investigation in the underlying native silty clay at this location.

Although coal tar wastes have currently been found in the area of the former gas holder, it is not known if such wastes existed elsewhere on the site during its operation. It is therefore not possible to determine a meaningful contaminant migration rate in the native soils as PAH concentrations in soils may be the result of migration of PAH from the area of the former gas holder or they may signify a discrete area of contamination.

PAH have been found in the native silty clay, as shown by the presence of PAH in boreholes II-2 and II-4 and to a lesser degree in borehole II-1. PAH are present even though no free coal tar waste was encountered in these holes. Based on the native soils in the area, i.e. silty clay, the migration rate of PAH through the soils is expected to be very slow and will depend on the bulk porosity of the clay soils (internal porosity and fissuring).

6.0 DISCUSSION OF RESULTS

The presence of the coal tar wastes on the site appears to be concentrated in the apparently localized deeper fill area in the vicinity of the former gas holder where oily product was encountered in fill at depths ranging from about 1.7 to 3.5 metres.

With respect to migration of contaminants, the dissolved phase will move with the groundwater flow but may show retardation. It is also possible for diffusion of the PAH through the soil matrix to occur. The LNAPL float on top of the groundwater and therefore will move in the general groundwater flow direction. Because LNAPL float they are also subject to dispersion as a residual product in a vertical direction by the rise and fall of the groundwater table. This vertical spreading of residual product in the soil can lead to volatilization and diffusion through the soil matrix or dissolution back into the groundwater when the soil and product are in contact with infiltrating water. If the LNAPL is retained in the soil and volatilizes, the vapours produced can move across gradient or upgradient with respect to the groundwater flow direction and therefore it is possible to locate vapours upgradient from dissolved sources. The vapour can also contribute to dissolved groundwater contamination hydraulically upgradient of the source due to dissolution by infiltrating recharge through the vadose zone.

The nature of DNAPL cause them to sink and they tend to migrate under gravity flow conditions. If the soils are fractured to any degree, the movement of DNAPL can be very rapid. DNAPL tend to form pools or pockets at the point where soil conditions such as a reduction in porosity or permeability prevent further downward movement. The

DNAPL pool can dissolve very slowly into the groundwater and thus provide a long term source for continued groundwater contamination.

The presence of free coal tar waste in borehole II-3 and high total PAH concentration (32,095 µg/L) in MW#3 groundwater near the south edge of the site, suggest that there is a potential for migration of coal tar wastes and/or contaminated groundwater to have occurred off-site. Based on the general groundwater flow directions, the contaminants will likely move towards the south (Water Street). The potential impact is likely to be on the sewers under Water Street. A section through the site and out into Water Street (Figure 15) shows the locations of the sewers and watermains under Water Street. The sewer most likely to be impacted first is the old egg-shaped sewer with an approximate depth of 3.6 metres. Based on groundwater levels measured in the site and those reported during the drilling of other boreholes in the area, this sewer is at or slightly below the groundwater table. If contaminants are migrating off of the site, they could enter the sewer bedding material or even the sewer itself depending on the integrity of sewer.

If DNAPL enter the sewer bedding or sewer they will migrate under gravity conditions to the low point of the bedding or sewer, or to a point where they can discharge. It is noted that the sewers within Water Street flow towards the west, except for the deeper tunnel which flows east. Based on drawings provided by the City of Cornwall, the west flowing sewers flow into a large chamber located on Water Street just west of Amelia Street. If DNAPL are migrating along the sewer bedding, this is a likely point of accumulation if there is no exit point.

LNAPL or dissolved products will also migrate along the sewer bedding but will generally follow the groundwater flow direction. It should be noted that since sewers generally control groundwater flow that LNAPL and DNAPL may migrate in a similar manner in the sewer bedding material. If they enter the sewer, they will flow along the sewer to the ultimate discharge of the sewer.

During the investigation, TIP II readings were made in catch basins and accessible manholes of the storm sewer system along Water Street near the site. No readings above background conditions were observed. These readings suggest that in the sewers tested, large quantities of PAH or VOC are not present.

Based on the results of this investigation wastes on the former gas plant site should not impact on the seniors building currently under construction at the corner of Amelia Street and First Street. The seniors building is upgradient both topographically and hydraulically from the site, and the soils between the site and the seniors building are silty clays which are not favourable transport media of contaminants such as PAH and VOC.

The results of the chemical analyses and TIP II readings during the drilling of borehole II-4, show that PAH are present in borehole II-4. This presence may indicate migration of PAH or may indicate a discrete area of contamination. As borehole II-4 is approximately 6 metres from the house on the west side of the parking lot, there is a potential that PAH may migrate towards the house. However, TIP II readings on the fill material taken in a borehole drilled next to the house in Phase I indicated no presence of contaminants and the fill material in borehole II-4 was also free of PAH or VOC contaminants based on TIP II readings and observations during the Phase II

drilling although PAH were found at depth in the underlying silty clay. With respect to coal tar wastes or contaminated groundwater entering the basement of the house, the groundwater table in the area of the house is approximately 3 to 4 metres below ground surface and therefore is below the level of the basement in the house.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the initial investigation of the former manufactured gas plant site in Cornwall, the following conclusions are made:

1) Coal tar and coal tar related contaminants are present in the soils and groundwater below the former plant site.

2) The coal tar contamination appears to be concentrated in the form of a free oil product within the fill material in the area of boreholes I-7, II-3 and II-5 which coincides with the former gas holder location. PAH and BTEX contamination of the on-site groundwater exists in the monitoring wells particularly in MW#3 which is downgradient of the former gas holder.

3) The presence of high PAH concentrations in borehole II-3 and MW#3 which are approximately 5 metres north of the curb on Water Street suggests it is likely that off-site migration of the coal tar wastes has occurred. B(a)P concentrations in the sample from MW#3 are 450 µg/l and B(a)P concentrations in the soil in borehole II-3 below the zone of coal tar wastes are between 3.5 and 1.5 µg/g. Based on the three phase nature of the sample from MW#3 there is potential that coal tar liquids as well as contaminated groundwater could enter the sewers and sewer bedding materials located under Water Street.

4) At the present time the coal tar wastes do not appear to be impacting on human health and safety due to the fact that the coal tar wastes are at a depth below the asphalt parking lot on the west side of the Water Street Arena.

5) Coal tar wastes or contaminated groundwater are not seeping into the adjacent residences to the west owned by Edgar Caza Holdings nor are they expected to.

6) There should be no impact from the site on the properties located to the north and east of the site. The properties to the north include the Cornwall Curling Club, the Julius Miller Furniture warehouse and the seniors building currently under construction at the corner of Amelia Street and First Street; the Water Street Arena is located to the east of the site. There should be no impact on the federal government building located on the west side of Amelia Street.

Based on the results of the initial investigation, the following recommendations are made:

1) The City of Cornwall and any other groups/individuals who have involvement with the property or adjacent properties should be notified of the findings of this study.

2) Additional works should be carried out to determine the possible extent of off-site migration of coal tar wastes particularly towards Water Street. In particular the location of any former service trenches that serviced the buildings that were on the site prior to the parking lot construction and the service trenches and sewer bedding material along Water Street

should be checked. If the coal tar wastes or coal tar contaminated groundwater are found in the trenches or sewer bedding, the inside of the sewers should be checked for coal tar related contaminants.

Yours truly,

GOLDER ASSOCIATES (EASTERN CANADA) LTD.

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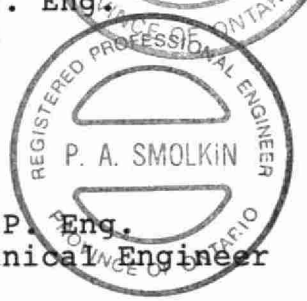

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TABLE 1

Results of GC/MS Waste Characterization
Analyses Phase I

GC/MS CHARACTERIZATION OF SOIL SAMPLE Borehole I-7 1.7 to 2 metres	CONCENTRATION ug/g
Acenaphthene	2
Fluorene	3
Phenanthrene	22
Anthracene	4
Carbazole	2
Methyl Phenanthrene	5
Cyclopentaphenanthrene	8
2-Phenylnaphthalene	4
Sulphur	28
Fluoranthene	22
Pyrene	18
Methyl 2-phenyl naphthalene	3
Methyl fluoranthene/pyrene Total (4 isomers)	14
Terphenyl Total (2 isomers)	4
Benzo(a)anthracene	9
Chrysene	9
Bis(2-ethylhexyl)phthalate	4
Benzo(b+k)fluoranthene	15
Benzo(j)fluoranthene	4
Benzo(a)pyrene	9
Benzo(e)pyrene	9
Perylene	4
Indenopyrene	5
Benzo(ghi)perylene	3
Dibenz(a,h)anthracene	2

TABLE 2

Results of Chemical Analyses on Groundwater Samples

Parameter (mg/l)	882354 MW#1	882355 MW#2	882356 MW#3	882357 Bailor Blank
pH (20 °C)	8.09	8.19	7.99	6.72
COD	< 10	< 10	760	< 10
TOC	5.5	5.0	40	< 1.0
Total Phenolics	< 0.1	< 0.1	0.77	< 0.1
Total Cyanide	< 0.01	< 0.01	< 0.01	< 0.01
Ammonia (as N)	< 0.01	< 0.01	0.014	< 0.01
TKN (as N)	< 0.3	< 0.3	< 0.3	< 0.3
Sulfide	< 0.001	0.032	< 0.001	< 0.001
Fluoride	< 0.1	< 0.1	< 0.1	< 0.1
Chloride	240	89	270	< 0.2
Nitrite (as N)	< 0.2	< 0.2	< 0.2	< 0.2
Bromide	< 0.8	< 0.8	< 0.8	< 0.8
Nitrate (as N)	< 0.2	< 0.2	< 0.2	< 0.2
Phosphate (as P)	< 0.8	< 0.8	< 0.8	< 0.8
Sulfate	70	100	18	< 1.0
Alkalinity (as CaCO3)	360	200	460	3.6
Calcium	170	68	180	0.14
Magnesium	52	30	48	0.015
Sodium	33	52	90	1.3
Potassium	3.1	11	17	< 0.4
Aluminum	0.13	0.10	0.21	0.37
Barium	0.072	0.16	0.38	0.006
Beryllium	< 0.001	< 0.001	< 0.001	< 0.001
Boron	0.25	0.28	0.60	0.74
Cadmium	< 0.005	< 0.005	< 0.005	< 0.005
Chromium	< 0.01	< 0.01	< 0.01	< 0.01
Cobalt	0.02	< 0.01	< 0.01	< 0.01
Copper	< 0.01	< 0.01	< 0.01	< 0.01
Iron	0.037	0.050	0.039	< 0.01
Lead	< 0.04	< 0.04	< 0.04	< 0.04
Manganese	0.91	0.90	0.98	< 0.005
Molybdenum	< 0.01	< 0.01	< 0.01	< 0.01
Nickel	0.018	< 0.01	< 0.01	< 0.01
Phosphorous	0.51	0.46	0.80	< 0.1
Silicon	9.6	5.5	9.2	< 0.05
Silver	< 0.01	< 0.01	< 0.01	< 0.01
Strontium	0.67	12	16	0.002
Sulfur	25	30	9.3	0.19
Thallium	< 0.05	< 0.05	< 0.05	< 0.05
Titanium	< 0.01	< 0.01	< 0.01	< 0.01
Vanadium	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	0.048	< 0.01	0.073	< 0.01
Zirconium	< 0.01	< 0.01	< 0.01	< 0.01

TABLE 3

Results of PAH Analyses on Groundwater Samples

Sample Description:		MW #1	MW #1 Re-Analysis	MW #2	MW #3	Bailor Blank	Method Blank
Zenon ID #:		882354	882354	882355	882356	882357	
Polyaromatic Hydrocarbons	MDL						
Naphthalene	0.01	0.039	0.051	0.39	9400	0.060	0.026
Acenaphthylene	0.01	0.026	0.023	0.14	1200	<	<
Acenaphthene	0.01	0.065	0.049	0.23	2100	<	<
Fluorene	0.01	0.040	0.039	0.16	2200	<	<
Phenanthrene	0.01	0.077	0.073	1.1	5400	<	<
Anthracene	0.01	< 0.02	< 0.02	0.26	1500	<	<
Fluoranthene	0.01	0.082	0.072	1.1	2600	<	<
Pyrene	0.01	0.090	0.083	1.1	3200	<	<
Benz(a)anthracene	0.01	0.034	0.028	0.35	710	<	<
Chrysene	0.01	0.038	0.031	0.46	770	<	<
Benzo(b+k)fluoranthene	0.01	0.066	0.055	0.78	880	<	<
Benzo(j)fluoranthene	0.01	0.012	0.015	0.12	160	<	<
Benzo(e)pyrene	0.01	0.013	0.012	0.24	210	<	<
Benzo(a)pyrene	0.01	0.018	0.017	0.37	450	<	<
Perylene	0.01	<	<	0.17	80	<	<
Indeno(1,2,3-cd)pyrene	0.01	0.038	0.035	0.81	560	<	<
Dibenz(ah)anthracene	0.01	<	<	0.09	95	<	<
Benzo(ghi)perylene	0.01	0.034	0.038	1.2	580	<	<
Surrogate Recovery (%)							
d-10 Anthracene		41	47	DIL	DIL	NR	NR
d-12 Benzo(a)pyrene		46	42	DIL	DIL	NR	NR

< (#) = Not detected at MDL (at #).
MDL = Minimum detection limits
NR = Not recovered
DIL = Analysis of the diluted extract forced the MS sensitivity below that required for surrogate determination.
All results are reported as µg/l except where noted.

TABLE 4

Results of BTEX Analyses on Water Samples

Sample Description:		MW #1	MW #2	MW #3	Bailor Blank	Method Blank
Zenon ID #:		882354	882355	882356	882357	
PARAMETER						
	MDL					
Benzene	50	<	<	2400	<	<
Toluene	50	<	<	960	<	<
Ethylbenzene	50	<	<	500	<	<
Xylenes	50	<	<	2100	<	<

< = Not Detected at MDL
MDL = Minimum detection limits
All results are reported as µg/l

TABLE 5

Results of Chemical Analyses on Soil Leachate Samples

	Parameter (mg/l)	882625 BH II-1 20.5' (6.2 m)	882626 BH II-2 8.5' (2.6 m)	882629 BH II-2 21' (6.4 m)	882630 BH II-3 3.5' (1.1 m)
leachate	Fluoride	< 0.1	< 0.1	< 0.1	< 0.1
	Chloride	< 0.2	< 0.2	< 0.2	6.0
	Nitrite (as N)	< 0.2	< 0.2	< 0.2	< 0.2
	Bromide	< 0.8	< 0.8	< 0.8	< 0.8
	Nitrate (as N)	< 0.2	< 0.2	< 0.2	1.0
	Phosphate (as P)	< 0.8	< 0.8	< 0.8	< 0.8
	Sulfate	< 1.0	3.0	5.0	5.0
	Arsenic	< 0.01	< 0.01	< 0.01	< 0.01
	Calcium	1500	57	1100	210
	Magnesium	27	7.6	38	5.0
	Sodium	1.8	8.1	3.1	9.4
	Potassium	3.2	2.2	5.0	2.9
	Aluminum	0.36	0.19	0.86	0.2
	Barium	1.3	0.065	1.6	0.16
	Beryllium	< 0.001	< 0.001	0.002	< 0.001
	Boron	0.14	0.16	0.17	0.15
	Cadmium	< 0.003	< 0.003	< 0.003	< 0.003
	Chromium	0.010	< 0.004	0.026	0.006
	Cobalt	0.01	< 0.01	< 0.01	< 0.01
	Copper	0.015	< 0.006	0.045	< 0.006
	Iron	0.98	0.095	1.5	0.11
	Lead	< 0.05	< 0.05	< 0.05	< 0.05
	Manganese	5.2	0.92	3.8	0.089
	Molybdenum	< 0.02	< 0.02	< 0.02	< 0.02
	Nickel	0.055	0.017	0.011	0.011
	Phosphorous	< 0.1	< 0.1	0.22	< 0.1
	Silicon	1.5	4.5	4.1	2.2
	Silver	< 0.01	< 0.01	< 0.01	< 0.01
	Strontium	3.4	0.23	2.6	0.59
	Sulphur	14	1.1	13	3.5
	Thallium	0.09	< 0.05	< 0.05	< 0.05
	Titanium	0.02	< 0.01	0.051	< 0.01
	Vanadium	< 0.02	< 0.02	< 0.02	< 0.02
	Zinc	0.043	0.019	0.045	0.04
	Zirconium	< 0.01	< 0.01	< 0.01	< 0.01

All results are reported as mg/l

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TABLE 5 (Continued)

Parameter (mg/l)	REG309 LQC	884566 BH II 1 4.11 m	884567 BH II 2 4.11 m	884568 BH II 4 -13.5' (4.11 m)	884569 BH II 4 -14.5' (4.42 m)
Fluoride	**2.4**	0.15	< 0.1	< 0.1	0.10
Chloride		6.6	22	23 / 23	13
Nitrite (as N)	**1**	< 0.2	< 0.2	< 0.2	< 0.2
Bromide		< 0.8	< 0.8	< 0.8	< 0.8
Nitrate (as N)	**10**	< 0.2	0.71	< 0.2	< 0.2
Phosph. (as P)		1.1	< 0.8	< 0.8	< 0.8
Sulfate		< 1.0	4.6	< 1.0	5.0
Arsenic	**0.05**	< 0.005	0.009	< 0.005	< 0.005
Mercury	**0.001**	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Selenium	**0.01**	< 0.005	< 0.005	< 0.005	< 0.005
Calcium		28	410	340	200
Magnesium		8.1	48	53	50
Sodium		5.4	7.3	6.3	4.3
Potassium		3.7	14	9.1	4.9
Aluminum		0.26	0.083	0.052	0.044
Barium	**1**	0.02	0.83	0.26	0.25
Beryllium		< 0.001	< 0.001	< 0.001	< 0.001
Boron	**5**	0.16	0.19	0.20	0.16
Cadmium	**0.005**	< 0.002	< 0.002	< 0.002	< 0.002
Chromium	**0.05**	< 0.004	0.006	< 0.004	< 0.004
Cobalt		< 0.01	0.01	< 0.01	< 0.01
Copper		< 0.006	< 0.006	< 0.006	< 0.006
Iron		0.094	0.055	< 0.01	0.031
Lead	**0.05**	< 0.04	< 0.04	0.11	< 0.04
Manganese		0.22	11	1.5	1.8
Molybdenum		< 0.02	< 0.02	< 0.02	< 0.02
Nickel		< 0.01	0.04	< 0.01	0.02
Phosphorus		2.0	< 0.1	0.13	0.13
Silicon		11	6.9	4.8	6.8
Silver	**0.05**	< 0.01	< 0.01	< 0.01	< 0.01
Strontium		0.13	1.5	0.79	0.59
Sulphur		0.82	4.9	2.7	4.3
Thallium		< 0.2	< 0.2	< 0.2	< 0.2
Titanium		< 0.01	< 0.01	< 0.01	< 0.01
Vanadium		< 0.02	< 0.02	< 0.02	< 0.02
Zinc		< 0.005	0.75	0.08	< 0.005
Zirconium		< 0.01	< 0.01	< 0.01	< 0.01

PAH ANALYSIS OF LEACHATES (µg/L)

TABLE 6 RESULTS OF PAH ANALYSES ON LEACHATE SAMPLES

ZENON ID			884566	884567	884568	884569
Parameter	**MDL**	**Method Blank**	**BH II-1** 4.11 m	**BHII-2** 4.11 m	**BH II-4 13.5'** (4.11 m)	**BH II-4 14.5'** (4.42 m)
Naphthalene	0.010	<	0.17	25	8.3	4.8
Acenaphthylene	0.010	<	<	2.2	0.71	0.035
Acenaphthene	0.015	<	0.083	22	8.4	0.054
Fluorene	0.015	<	0.053	10	5.8	0.020
Phenanthrene	0.010	<	0.20	11	8.8	0.043
Anthracene	0.010	<	0.022	1.1	0.24	Trace
Fluoranthene	0.010	<	0.017	0.40	0.28	Trace
Pyrene	0.010	<	0.019	0.44	0.33	Trace
Benzo(a)anthracene	0.010	<	<	<	<	<
Chrysene	0.010	<	<	<	<	<
Benzo(b+k)fluoranthene	0.010	<	<	<	<	<
Benzo(a)pyrene	0.010	<	<	<	<	<
Indeno(1,2,3-c,d)pyrene	0.010	<	<	<	<	<
Dibenzo(a,h)anthracene	0.010	<	<	<	<	<
Benzo(g,h,i)perylene	0.010	<	<	<	<	<
Surrogate Recovery %						
d10-Acenaphthene		70	67	74	85	83
d10-Anthracene		75	70	75	54	39
d12-Benzo(a)pyrene		70	67	79	48	27

MDL - Minimum Detection Limit
< - Less than MDL
Trace - Below quantification level

TABLE 7

Results of PAH Analyses on Soil Samples

Sample Description:		BH II-1 10'	BH II-2 13.5'	BH II-2 17'	BH II-2 21'	BH II-3 11'	BH II-3 13.5'
Zenon ID #:		882624	882627	882628	882629	882631	882632
		(3.05 m)	(4.11 m)	(5.18 m)	(6.40 m)	(3.35 m)	(4.11 m)
Polyaromatic Hydrocarbons	MDL						
Naphthalene	0.03	<	<	<	<	0.11	0.10
Acenaphthylene	0.01	<	<	<	<	11	1.1
Acenaphthene	0.01	<	0.022	<	<	2.1	0.39
Fluorene	0.01	<	0.016	<	<	18	34
Phenanthrene	0.01	0.013	0.068	<	0.025	50	15
Anthracene	0.01	<	0.014	<	<	12	3.8
Fluoranthene	0.01	0.023	0.045	<	0.040	24	9.7
Pyrene	0.01	0.068	0.046	<	0.094	29	12
Benz(a)anthracene	0.01	0.022	<	<	0.020	6.0	2.1
Chrysene	0.01	0.045	0.016	<	0.084	6.7	2.7
Benzo(b+k)fluoranthene	0.01	<	0.023	<	<	8.0	2.9
Benzo(j)fluoranthene	0.01	<	<	<	<	1.2	0.48
Benzo(e)pyrene	0.01	<	<	<	<	1.8	0.69
Benzo(a)pyrene	0.01	<	<	<	<	3.7	1.5
Perylene	0.01	<	<	0.017	0.066	0.70	0.26
Indeno(1,2,3-cd)pyrene	0.01	<	0.010	<	<	3.0	1.1
Dibenz(ah)anthracene	0.01	<	<	<	<	0.73	0.28
Benzo(ghi)perylene	0.01	<	0.013	<	<	3.9	1.6
Surrogate Recovery (%)							
d-10 Anthracene		100	94	75	108	91	123
d-12 Benzo(a)pyrene		113	83	40	107	86	91

< (#) = Not detected at MDL (at #).
MDL = Minimum detection limits
DIL = Analysis of the diluted extract forced the MS sensitivity below that required for surrogate determination.
All results are reported as µg/g.

TABLE 7 (Continued)

Sample Description:		BH II-4 13.5'	BH II-4 18.5'	BH II-5 11'	BH II-5 18.5'	
Zenon ID #:		882633	882634	882635	882636	Method Blank
		(4.11 m)	(5.64 m)	(3.35 m)	(5.64 m)	
Polyaromatic Hydrocarbons	MDL					
Naphthalene	0.02	0.036	<	88	0.042	<
Acenaphthylene	0.01	<	<	1.0	0.85	<
Acenaphthene	0.01	0.031	0.014	59	0.74	<
Fluorene	0.01	0.089	0.012	54	3.7	<
Phenanthrene	0.01	0.071	0.024	150	10	<
Anthracene	0.01	0.71	<	76	2.4	<
Fluoranthene	0.01	0.13	0.014	93	4.1	<
Pyrene	0.01	0.037	0.043	77	4.8	<
Benz(a)anthracene	0.01	0.35	<	42	0.67	<
Chrysene	0.01	0.39	<	53	0.81	<
Benzo(b+k)fluoranthene	0.01	0.37	<	61	1.1	<
Benzo(j)fluoranthene	0.01	0.051	<	6.6	0.19	<
Benzo(e)pyrene	0.01	0.059	<	13	0.29	<
Benzo(a)pyrene	0.01	0.18	<	22	0.59	<
Perylene	0.01	0.018	<	4.5	0.16	<
Indeno(1,2,3-cd)pyrene	0.01	0.14	<	27	0.49	<
Dibenz(ah)anthracene	0.01	0.036	<	4.9	0.11	<
Benzo(ghi)perylene	0.01	0.14	<	27	0.71	<
Surrogate Recovery (%)						
d-10 Anthracene		76	76	DIL	111	66/96
d-12 Benzo(a)pyrene		79	53	DIL	90	23/84

< (#) = Not detected at MDL (at #).
MDL = Minimum detection limits
DIL = Analysis of the diluted extract forced the MS sensitivity below that required for surrogate determination.
All results are reported as µg/g.

TABLE 8

Ontario Drinking Water Objectives

TABLE 1
Maximum Acceptable Concentrations
Parameters Related to Health

Parameter*	Concentration (mg/L)
Arsenic	0.05
Barium	1.0
Boron	5.0
Cadmium	0.005
Chromium	0.05
Cyanide (Free)	0.2
Fluoride	2.4
Lead	0.05
Mercury	0.001
Nitrate (as N)**	10.0
Nitrite (as N)	1.0
Nitrilotriacetic Acid (NTA)	0.05
Pesticides	
(Aldrin + Dieldrin	0.0007
(Carbaryl	0.07
(Chlordane	0.007
(DDT	0.03
(Diazinon	0.014
(Endrin	0.0002
***(Heptachlor + Heptachlor Epoxide	0.003
(Lindane	0.004
(Methoxychlor	0.1
(Methyl Parathion	0.007
(Parathion	0.035
(Toxaphene	0.005
2,4-D	0.1
2,4,5-TP	0.01
Radionuclides****	—
Selenium	0.01
Silver	0.05
Trihalomethanes*****	0.35
Turbidity	1 FTU

* Unless otherwise stated the limits for each substance refer to the sum of all forms present.

** Where both nitrate and nitrite are present, the total nitrate plus nitrite-nitrogen should not exceed 10 mg/L.

*** When more than one of these pesticides is present, the "total pesticides" shall not exceed the sum of their MAC's or 0.1 mg/L whichever is the lesser.

**** Maximum acceptable concentrations and target concentrations for radionuclides can be found in Table 3, section 2.4.

***** The term "trihalomethanes" comprises chloroform, bromodichloromethane, chlorodibromomethane, and bromoform, and their concentration as determined by the gas sparge or purge equivalent method (i.e. actual concentration) should not exceed 0.35 mg/L at any time.

TABLE 2
Maximum Desirable Concentrations
Parameters Related to Aesthetic Quality

Parameter	Concentration*
Chloride	250
Colour	5 (TCU) **
Copper	1.0
Iron	0.3
Manganese	0.05
Methane	3 L/m^3
Odour	Inoffensive
Organic Nitrogen***	0.15
Phenols	0.002
Sulphate	500
Sulphide	Inoffensive
Taste	Inoffensive
Temperature	15°C
Total Dissolved Solids	500
Total Organic Carbon	5.0
Zinc	5.0

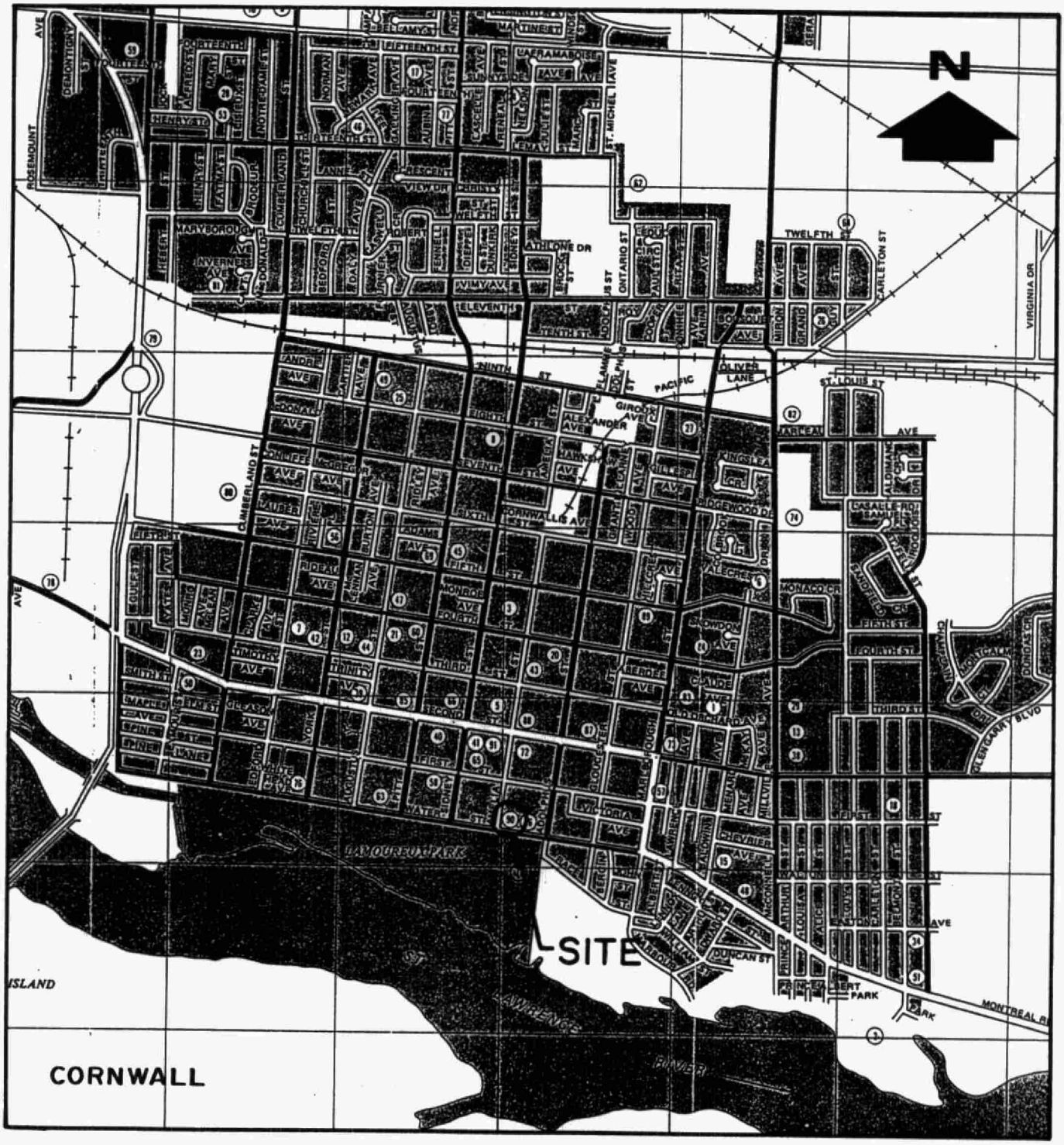
* Unless otherwise indicated, the maximum desirable concentrations are expressed in mg/L.

** True Colour Units.

*** Total kjeldahl nitrogen minus ammonia nitrogen.

KEY PLAN

FIGURE 1



SCALE 1:20,600 (approx.)

Date MAR. 25, 1988

Project 881-2705

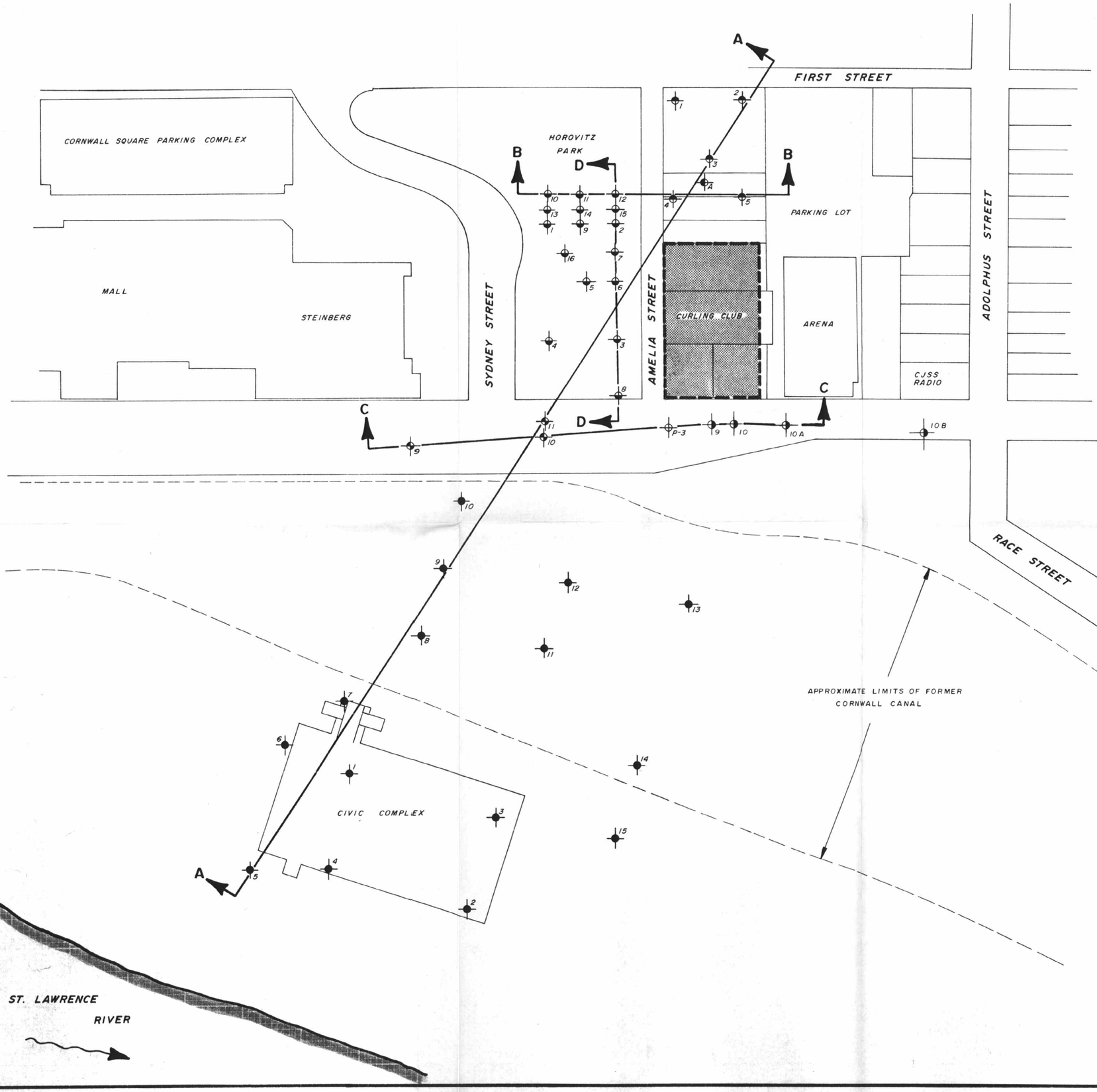
Golder Associates

Drawn JC

Chkd. BAW

LOCATION OF BOREHOLES (PREVIOUS INVESTIGATIONS)

FIGURE 2



LEGEND

- BOREHOLE LOCATION IN PLAN, PREVIOUS INVESTIGATION BY GOLDER ASSOCIATES, REPORT No. 752050
- BOREHOLE LOCATION IN PLAN, PREVIOUS INVESTIGATION BY GOLDER ASSOCIATES, REPORT No. 742101
- BOREHOLE LOCATION IN PLAN, PREVIOUS INVESTIGATION BY GOLDER ASSOCIATES, REPORT No. 742079-1
- BOREHOLE LOCATION IN PLAN, PREVIOUS INVESTIGATION BY ST. LAWRENCE TESTING, REPORT No. 3C38
- BOREHOLE LOCATION IN PLAN, PREVIOUS INVESTIGATION BY ST. LAWRENCE TESTING, REPORT No. 7C31
- BOREHOLE LOCATION IN PLAN, PREVIOUS INVESTIGATION BY SOLROC CONSULTANT LTD., REPORT No. RA36-88286
- BOREHOLE LOCATION IN PLAN, PREVIOUS INVESTIGATION BY E.M. PETO ASSOCIATES LTD. REPORT No. 6113
- APPROXIMATE LIMITS OF FORMER GAS PLANT SITE
- CROSS-SECTION IN PLAN, REFER TO FIGURES 3 TO 5 FOR DETAILED CROSS-SECTION IN PROFILE.

REFERENCE

PLAN SUPPLIED BY CITY OF CORNWALL, PUBLIC WORKS DEPARTMENT.

N

SCALE

1:1200 (metric)
1"=100' (imp.)

SPECIAL NOTE : THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT

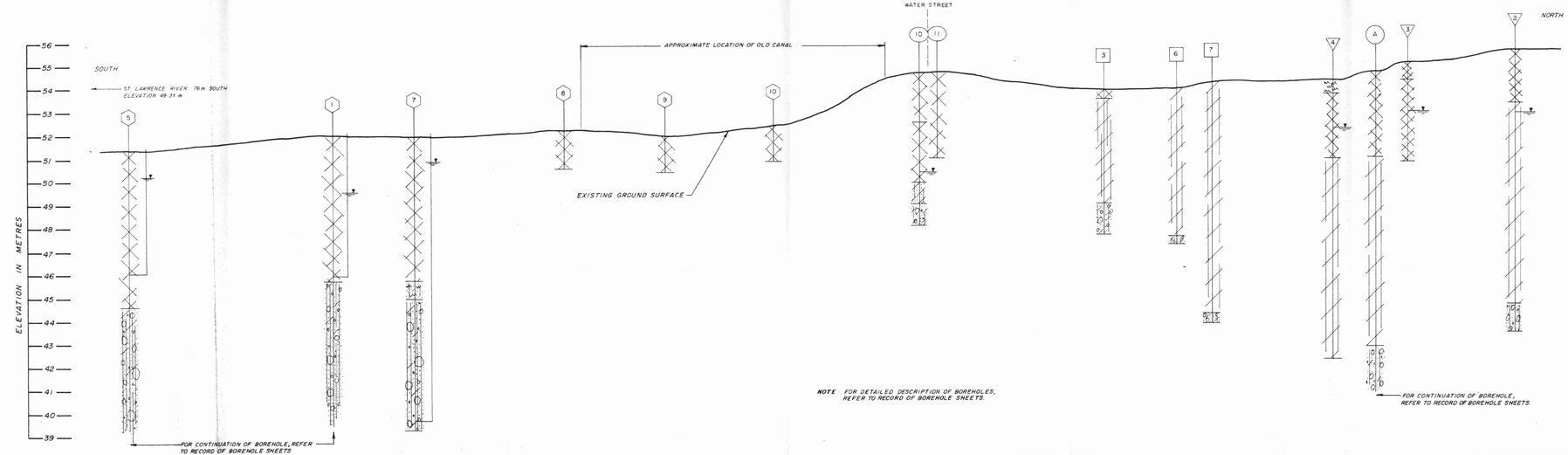
Date MAR 29, 1988
Project 881-2705

Golder Associates

Drawn JC
Chkd RAW
PAS

SOILS PROFILE
SECTION A-A

FIGURE 3



NOTE FOR DETAILED DESCRIPTION OF BOREHOLES, REFER TO RECORD OF BOREHOLE SHEETS.

LEGEND

- 10 — BOREHOLE IN ELEVATION, PREVIOUS INVESTIGATION BY GOLDER ASSOCIATES, REPORT No. 752050
- WATER LEVEL IN ELEVATION
- STANDPIPE IN ELEVATION
- 9 — BOREHOLE IN ELEVATION, PREVIOUS INVESTIGATION BY GOLDER ASSOCIATES, REPORT No. 742101
- 3 — BOREHOLE IN ELEVATION, PREVIOUS INVESTIGATION BY ST. LAWRENCE TESTING, REPORT No. 3C38
- 2 — BOREHOLE IN ELEVATION, PREVIOUS INVESTIGATION BY ST. LAWRENCE TESTING, REPORT No. 7C31
- A — BOREHOLE IN ELEVATION, PREVIOUS INVESTIGATION BY SOLROC CONSULTANTS, REPORT No. RA36-88286

SOIL STRATIGRAPHY

- TOPSOIL
- FILL
- FIRM TO STIFF GREY BROWN BECOMING GREY SILTY CLAY
- ALLUVIUM
- SILTY SAND TILL
- SANDY SILT TILL

SCALE HORIZ. 1:600
VERT. 1:75

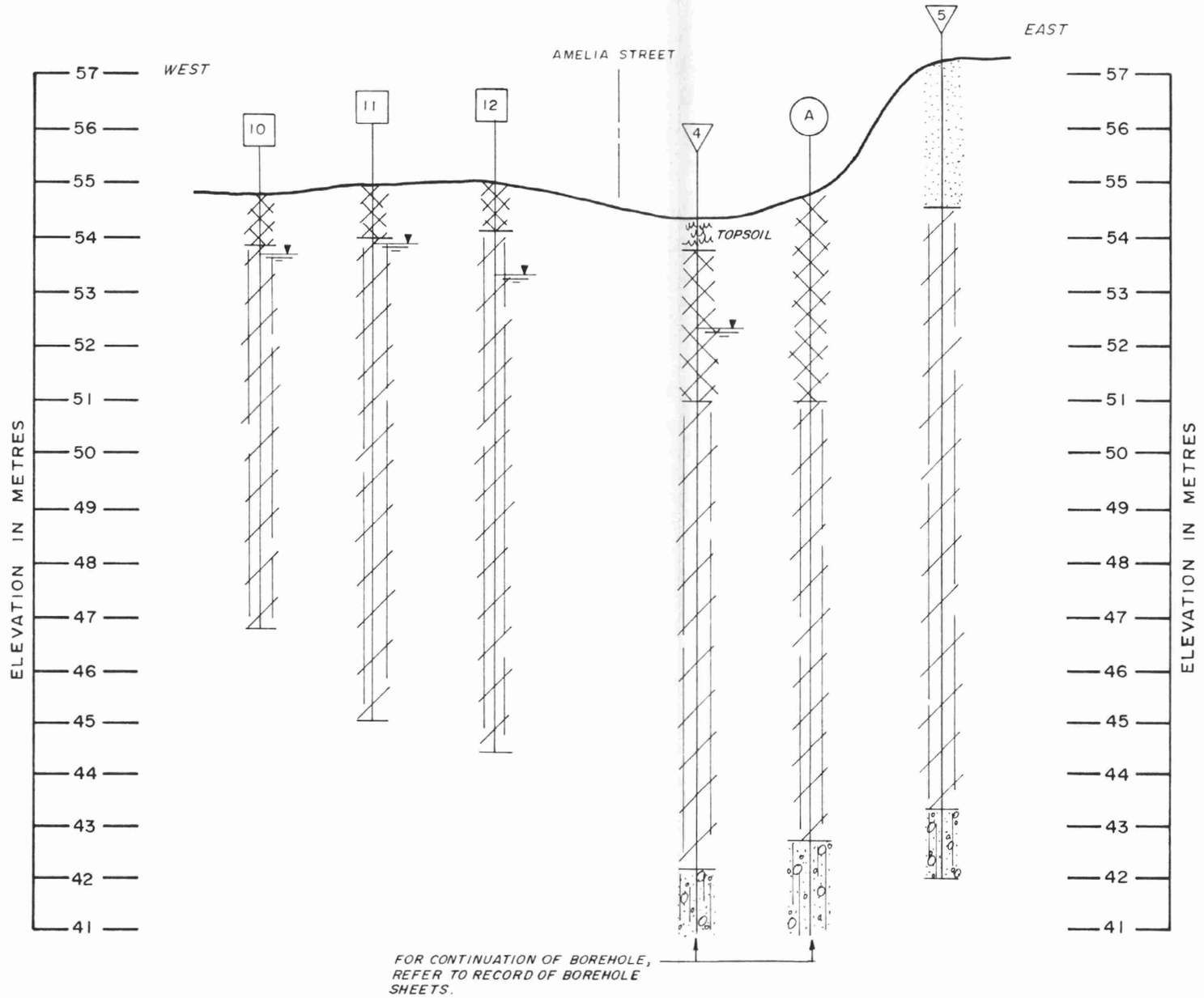
Date MAR 17, 1988
Project 881-2705

Golder Associates

Drawn JC
Chkd. BAW
Appd. DES

SOILS PROFILE
SECTION B-B

FIGURE 4



LEGEND

11 — BOREHOLE IN ELEVATION, PREVIOUS INVESTIGATION BY ST. LAWRENCE TESTING, REPORT No. 3C38

WATER LEVEL IN ELEVATION

4 — BOREHOLE IN ELEVATION, PREVIOUS INVESTIGATION BY ST. LAWRENCE TESTING, REPORT No. 7C31

A — BOREHOLE IN ELEVATION, PREVIOUS INVESTIGATION BY SOLROC CONSULTANTS, REPORT No. RA36-88286

SOIL STRATIGRAPHY

FILL

SAND

FIRM TO STIFF GREY BROWN BECOMING GREY **SILTY CLAY**

SILTY SAND **TILL**

NOTES: 1) FOR DETAILED SOIL STRATIGRAPHY, REFER TO RECORD OF BOREHOLE SHEETS.

2) THIS REPORT TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT.

SCALE: HORIZ. 1:600
VERT. 1:75

Date MAR. 17, 1988

Project 881-2705

Golder Associates

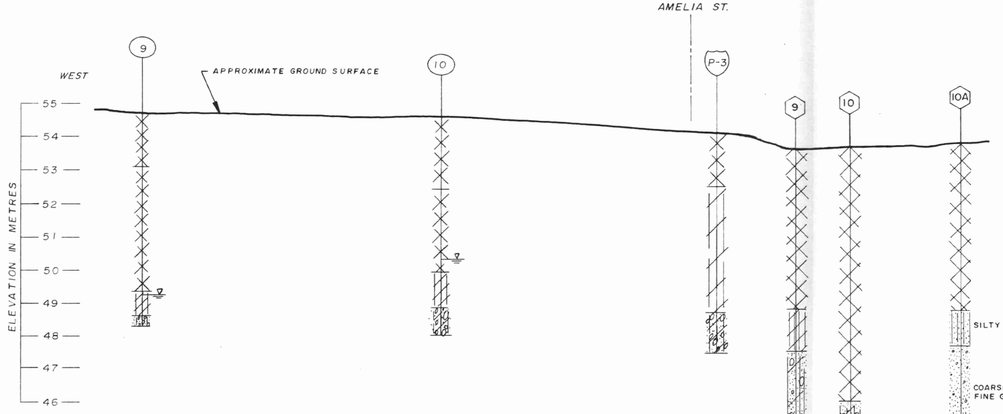
Drawn JC

Chkd BAW

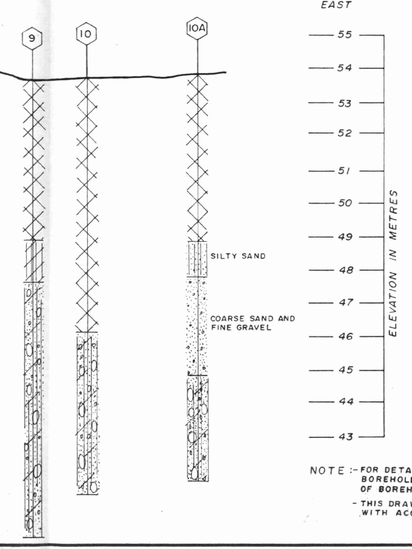
Appd PAS

SOILS PROFILE
(SECTIONS C-C & D-D)

FIGURE 5

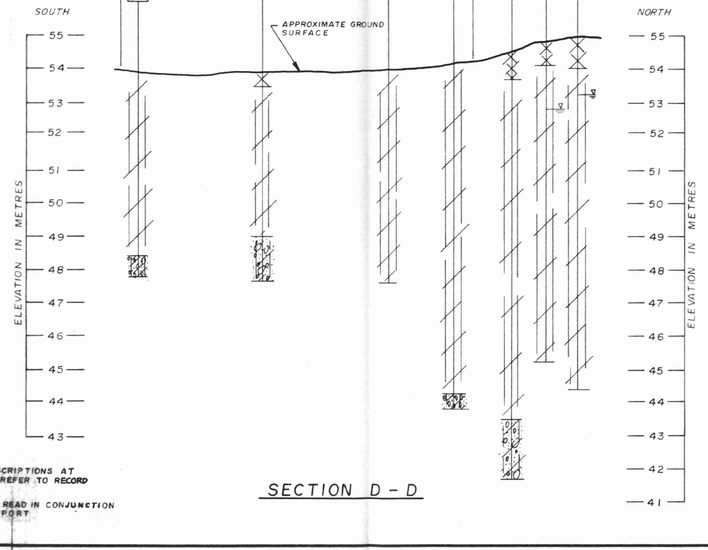


SECTION C-C



NOTE :- FOR DETAILED SOIL DESCRIPTIONS AT BOREHOLE LOCATIONS, REFER TO RECORD OF BOREHOLE SHEETS.

- THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT



SECTION D-D

LEGEND

- 15 — BOREHOLE IN ELEVATION, PREVIOUS INVESTIGATION BY ST. LAWRENCE TESTING, REPORT # 3038
- WATER LEVEL IN ELEVATION
- STRATA PLOT
- 10 — BOREHOLE IN ELEVATION, PREVIOUS INVESTIGATION BY GOLDER ASSOCIATES, REPORT No. 752050
- P-3 — BOREHOLE IN ELEVATION, PREVIOUS INVESTIGATION BY GOLDER ASSOCIATES, REPORT No. 742079-1
- 9 — BOREHOLE IN ELEVATION, PREVIOUS INVESTIGATION BY E.M. PETO ASSOCIATES, REPORT 6113

SOIL STRATIGRAPHY

- FILL
- FIRM TO STIFF GREY BROWN BECOMING GREY SILTY CLAY
- GLACIAL TILL

SCALE HORIZ 1:600
VERT 1:75

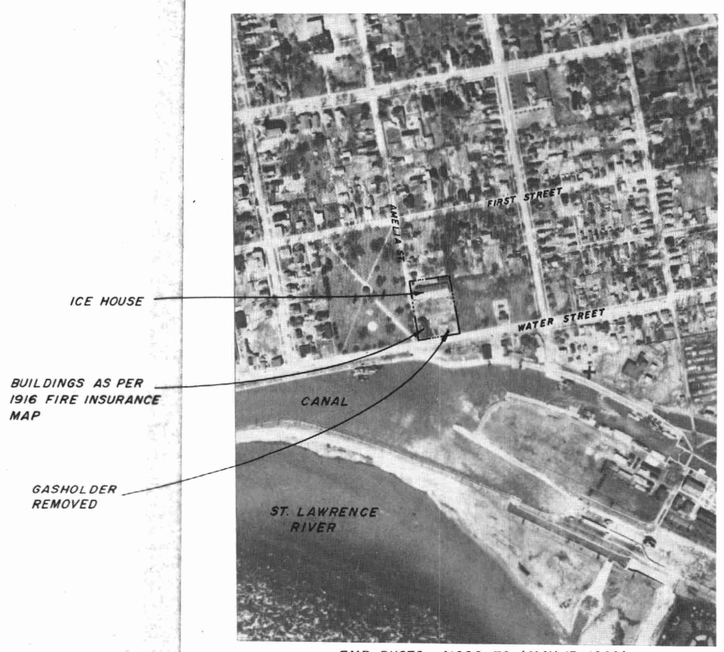
Date MAR 17, 1988
Project 881-2705

Golder Associates

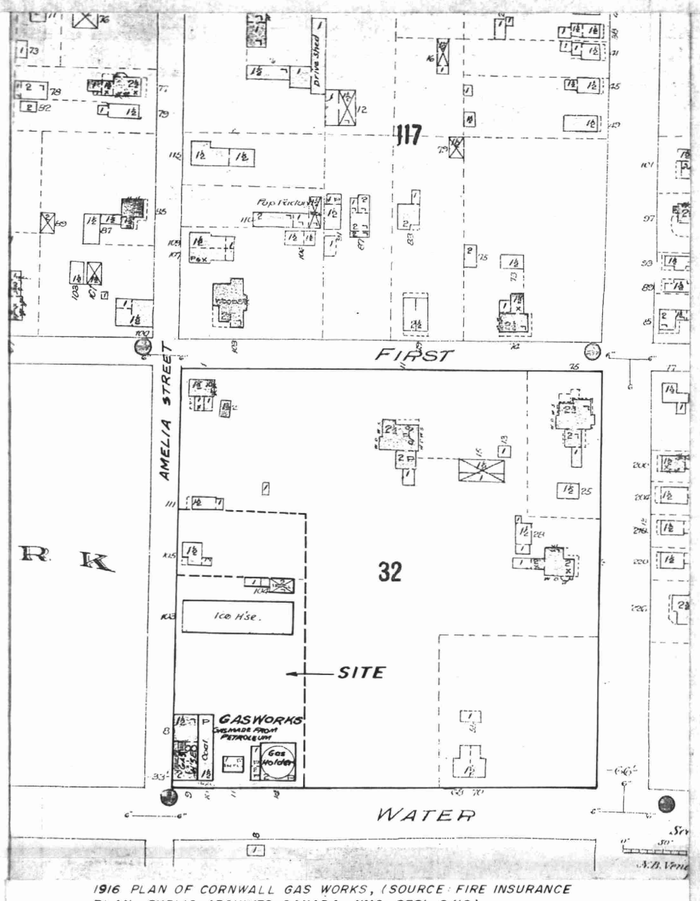
Drawn S.L.
Chkd. DAN
Appd. [illegible]

HISTORICAL SITE USE

FIGURE 6

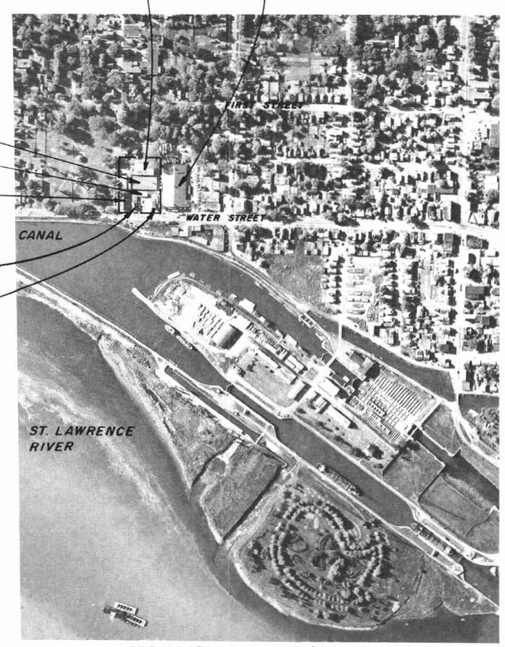


EMR PHOTO - A1080-72 (MAY 13, 1929)
APPROX. SCALE 1:4900

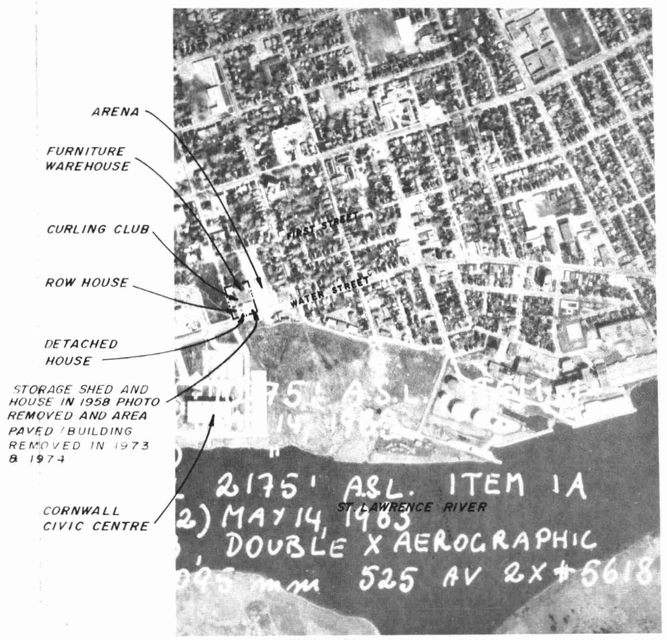


1916 PLAN OF CORNWALL GAS WORKS, (SOURCE: FIRE INSURANCE PLAN, PUBLIC ARCHIVES CANADA, NMC-9381, 6/12)

APPROX. SCALE 1:1440



EMR PHOTO - A15993-81 (MAY 27, 1958)
APPROX. SCALE 1:5800



EMR PHOTO - A26249-1 (MAY 14, 1983)
APPROX. SCALE 1:9800

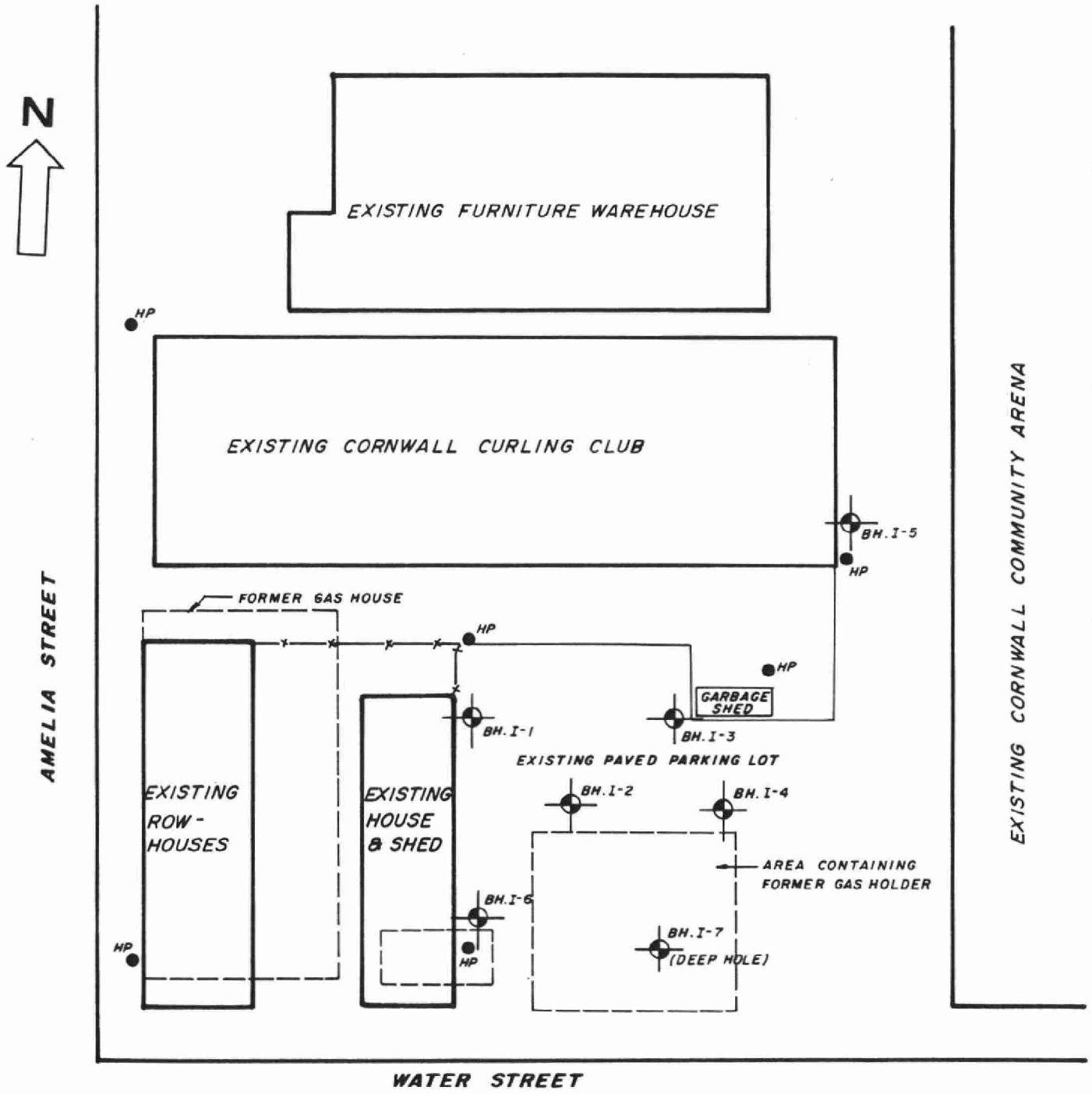
Date MAR. 22, 1988
Project 881-2705

Golder Associates

Drawn JC
Chkd. RAW

LOCATION OF PHASE I BOREHOLES

FIGURE 7



LEGEND

- BOREHOLE LOCATION IN PLAN
- HP HYDRO POLE
- APPROXIMATE LOCATIONS OF FORMER GAS WORKS

SCALE

1: 500
(approx.)

SPECIAL NOTE

THIS DRAWING TO READ IN CONJUNCTION WITH ACCOMPANYING REPORT

Date MAR. 29, 1988
Project 881-2705

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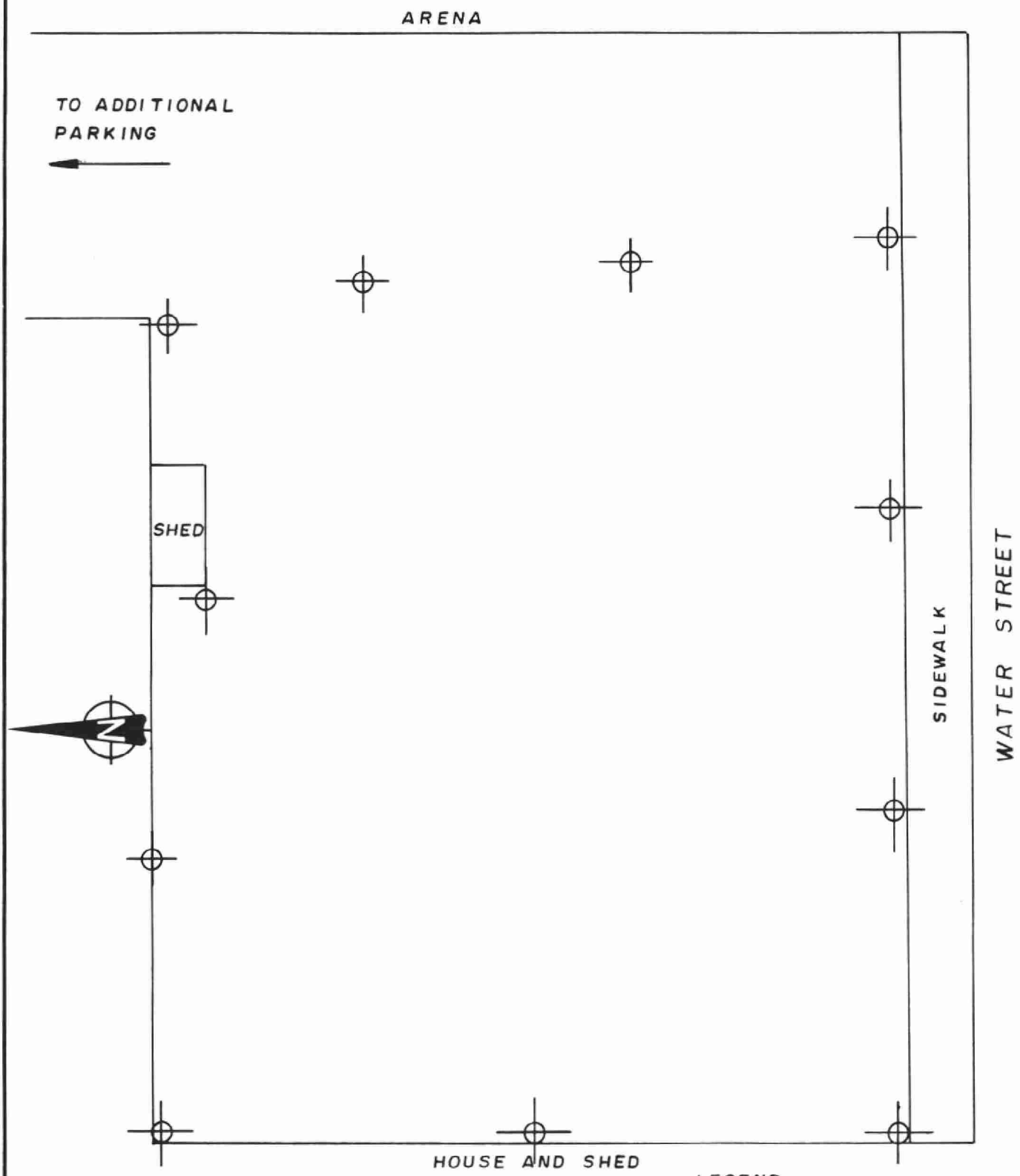
Drawn JC
Chkd. BAW

LOCATION OF AIR QUALITY MONITORING STATIONS

FIGURE 8



SPECIAL NOTE

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT.

LEGEND

MONITORING STATION IN PLAN

SCALE 1:200

Date OCT 14, 1988

Project 881-2705

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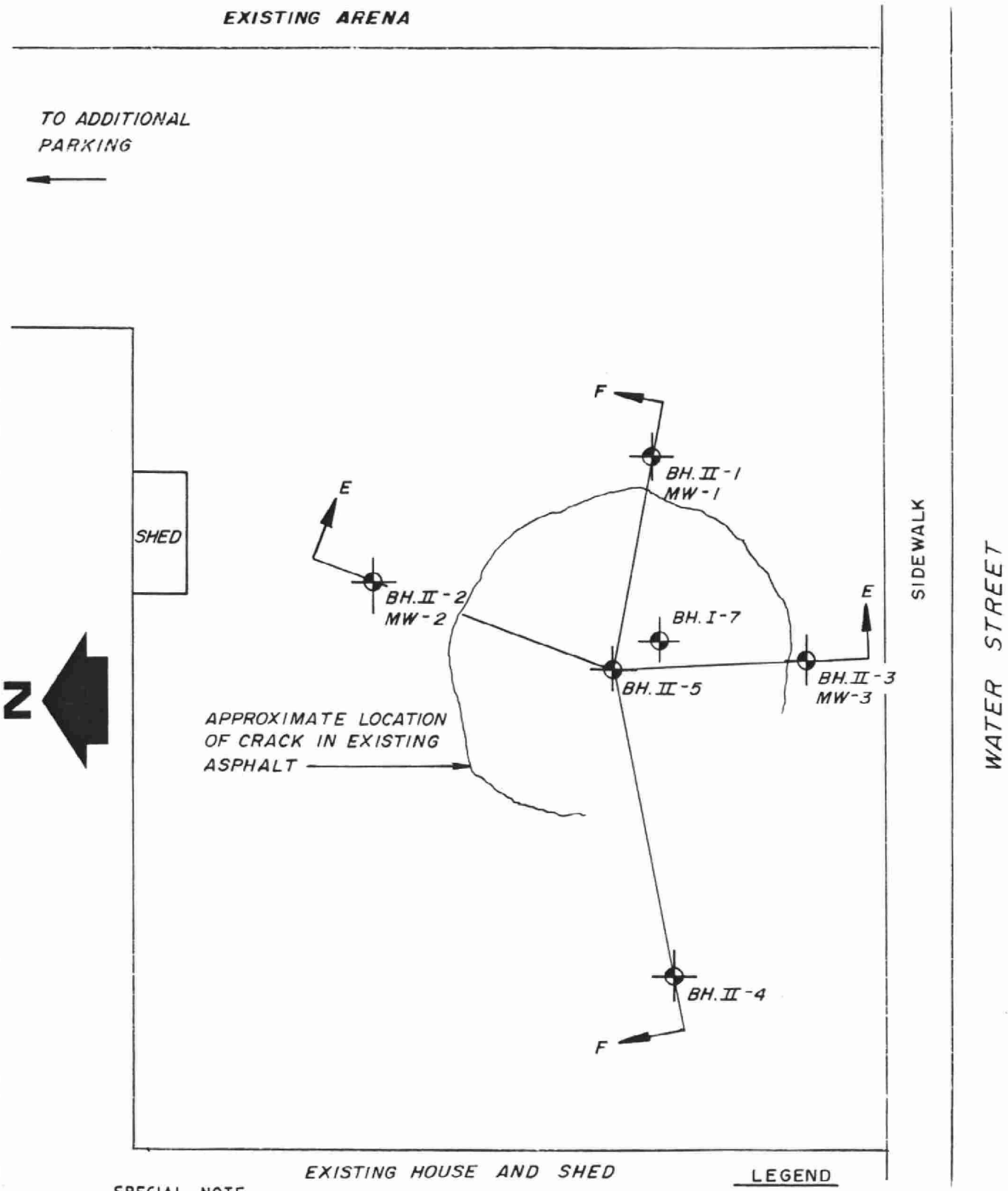
Drawn S.L

Chkd.

LOCATION OF PHASE II BOREHOLES
(IN PAVED PARKING LOT)

FIGURE 9



SPECIAL NOTE

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT.

SCALE 1:200

LEGEND

BOREHOLE LOCATION IN PLAN

SECTION LOCATION IN PLAN

MW MONITORING WELL

Date JUNE 1, 1988

Project 881-2705

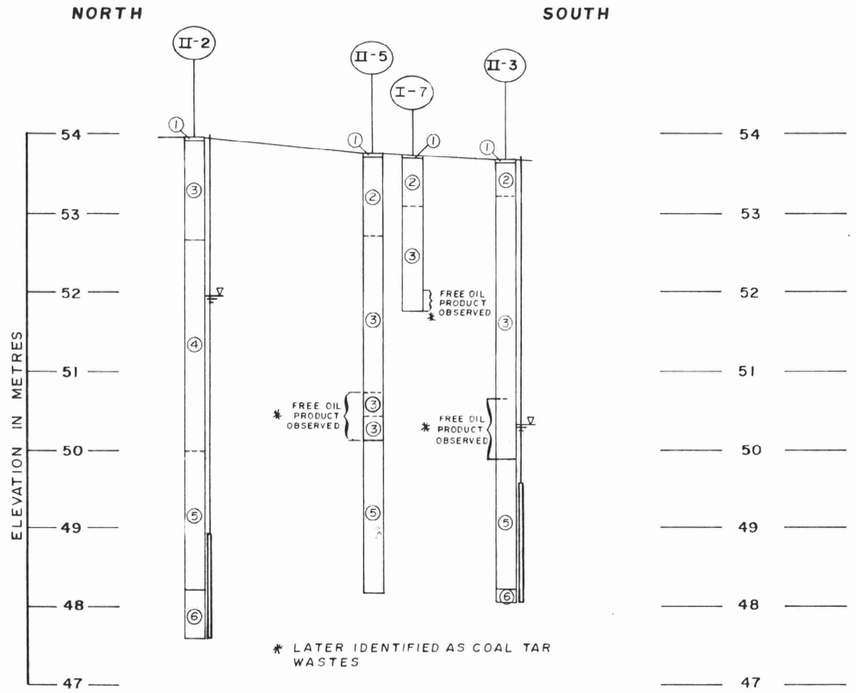
Golder Associates

Drawn JC

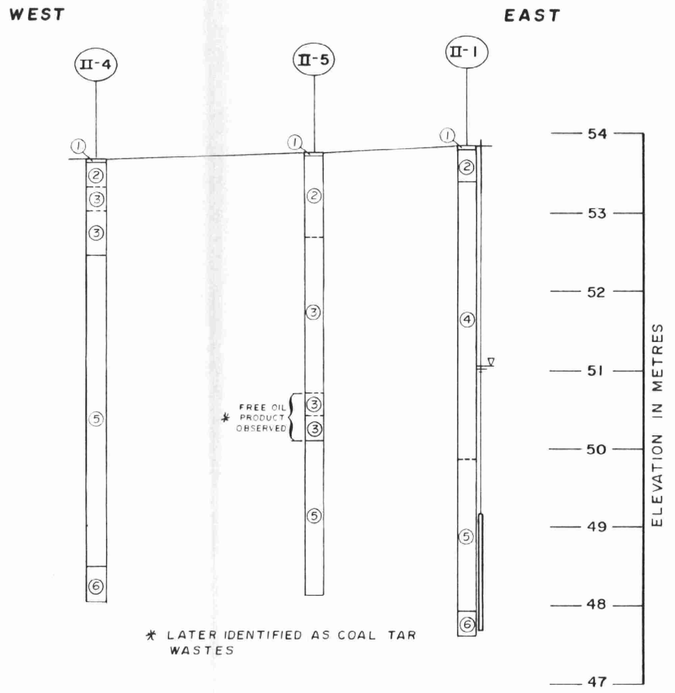
Chkd. PAS

SOILS PROFILE SECTIONS E-E, F-F

FIGURE 10



SECTION E-E



SECTION F-F

LEGEND

II-1 BOREHOLE LOCATION IN ELEVATION

WATER LEVEL IN ELEVATION

② STRATA IDENTIFICATION (see below for description)

WELL SCREEN IN ELEVATION

SOILS STRATIGRAPHY

① **ASPHALT**

② **FILL** - SAND WITH GRAVEL

③ **FILL** - GENERALLY SILTY CLAY WITH MISCELLANEOUS RUBBLE; SOME ORGANIC MATERIAL

④ **SILTY CLAY** (WEATHERED CRUST)

⑤ **SILTY CLAY**

⑥ **GLACIAL TILL**

SPECIAL NOTES (1) THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT
(2) FOR DETAILED SOIL DESCRIPTIONS AT BOREHOLE LOCATIONS, REFER TO RECORD OF BOREHOLE SHEETS
(3) SECTION LOCATIONS SHOWN ON FIGURE 1

SCALE HORIZ. 1:200
VERT. 1:50

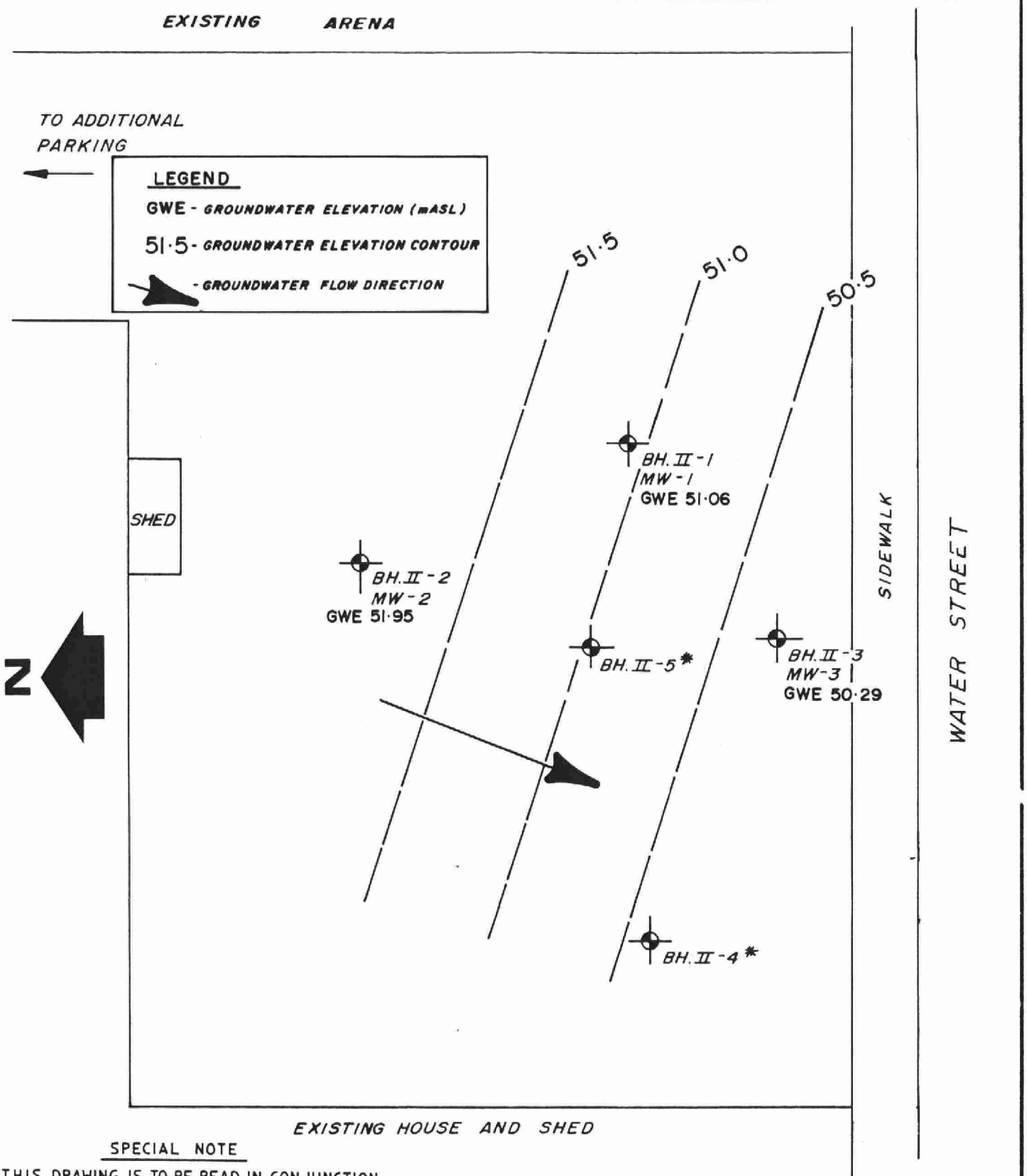
Date JULY 19, 1988
Project 881-2705

Golder Associates

Drawn S.L
Chkd PAZ
Appd

GROUNDWATER ELEVATIONS
MAY 25, 1988

FIGURE 11



SPECIAL NOTE

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT.

SCALE 1:200

* NO MONITORING WELL INSTALLATION

Date JUNE 1, 1988

Project 881-2705

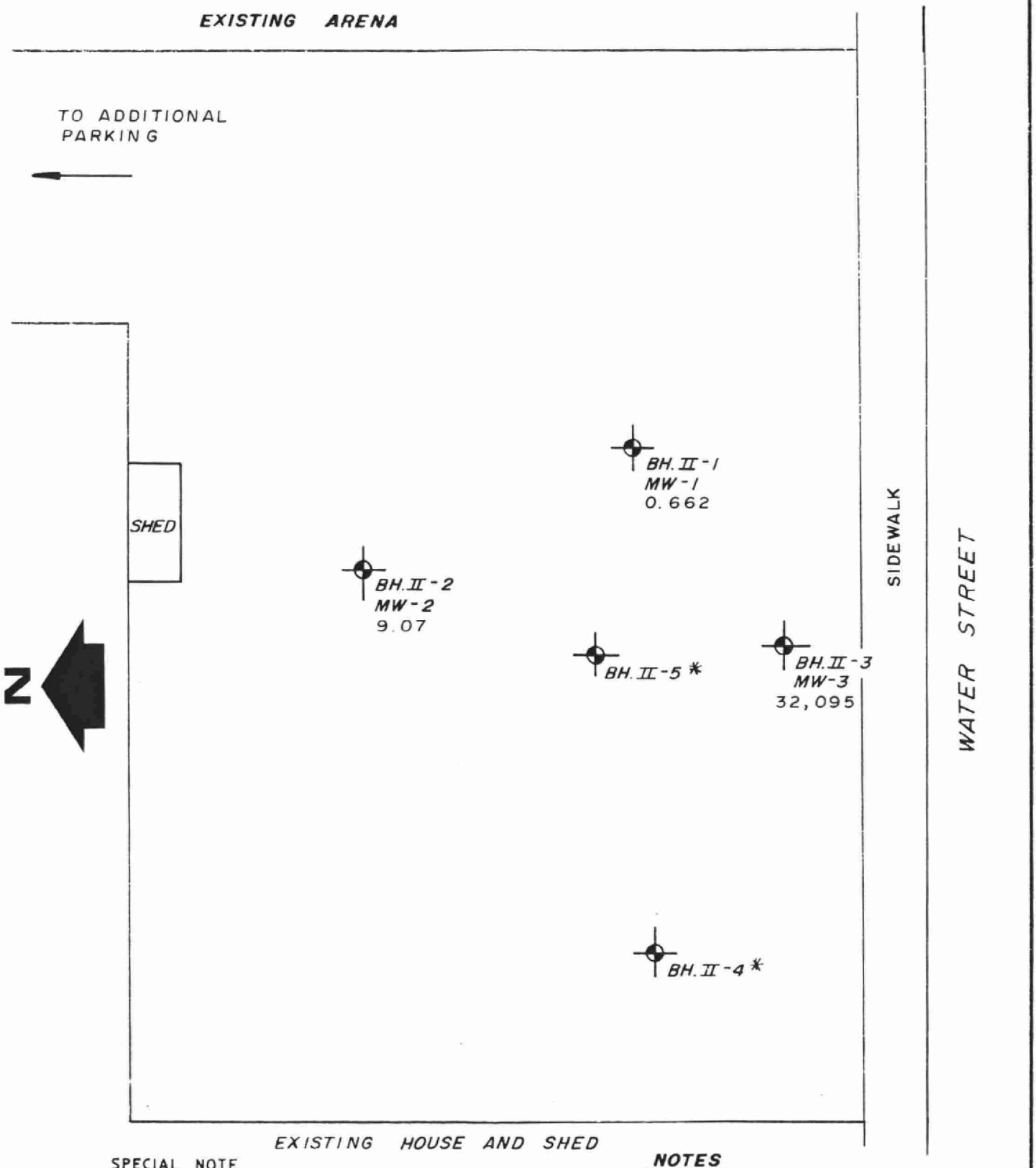
Golder Associates

Drawn JC

Chkd. PAS

TOTAL GROUNDWATER PAH CONCENTRATIONS IN (µg/L)

FIGURE 12



SPECIAL NOTE

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT.

SCALE 1:200

NOTES

1) TOTAL IS SUM OF 18 INDIVIDUAL PAH ANALYSES

2) * NO MONITORING WELL INSTALLATION

Date JUNE 1, 1988

Project 881-2705

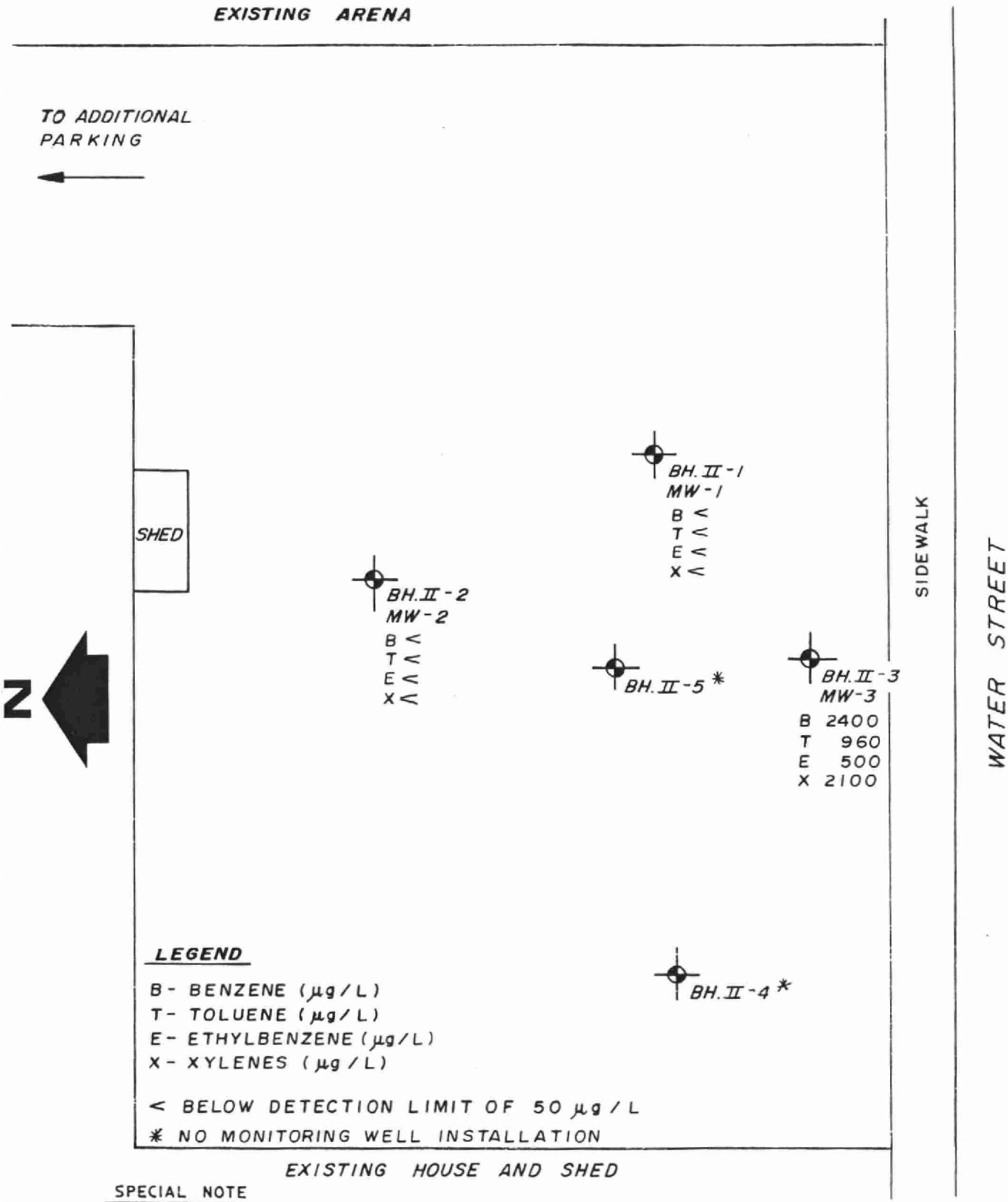
Golder Associates

Drawn JC

Chkd. PAS

GROUNDWATER BTEX CONCENTRATIONS (µg/L)

FIGURE 13



SPECIAL NOTE

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT.

SCALE 1:200

Date JUNE 1, 1988

Project 881-2705

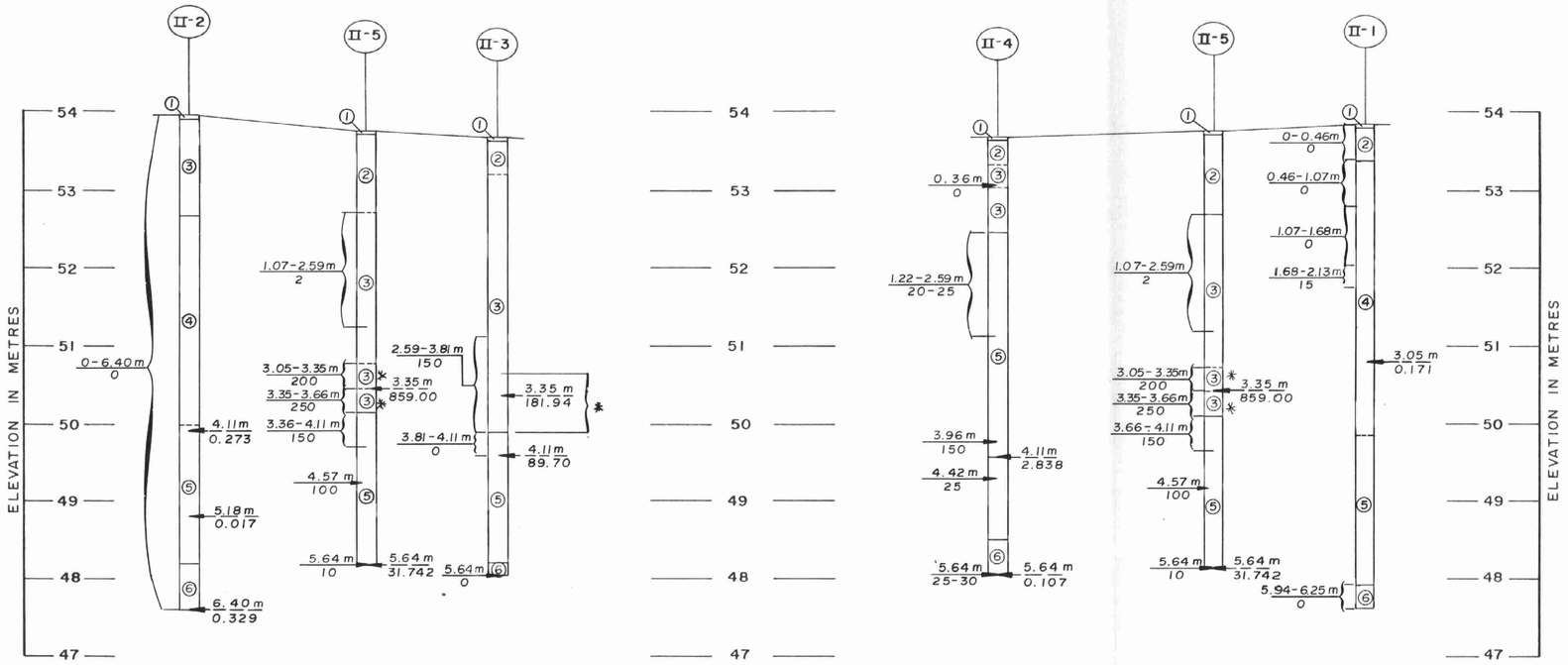
Golder Associates

Drawn JC

Chkd. PAS

TOTAL PAH CONCENTRATION IN SOILS (µg/g)

FIGURE 14



LEGEND

4.57m / 100 — DEPTH — TIP READING (ppm CALIBRATED TO ISOBUTYLENE)

3.35 m / 859.00 — DEPTH OF SAMPLE — TOTAL PAH (µg/g)

* FREE OIL PRODUCT OBSERVED (LATER IDENTIFIED AS COAL TAR WASTES)

NOTE: FOR STRATIGRAPHY DESCRIPTION REFER TO FIGURE 5

SCALE HORIZ. 1:200
VERT. 1:50

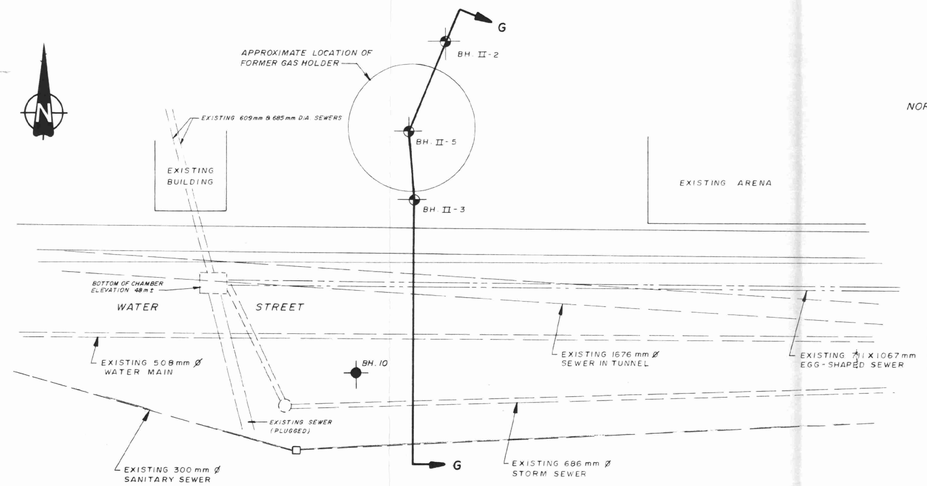
SPECIAL NOTE
THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT

Date JULY 19, 1988
Project 881-2705

Golder Associates

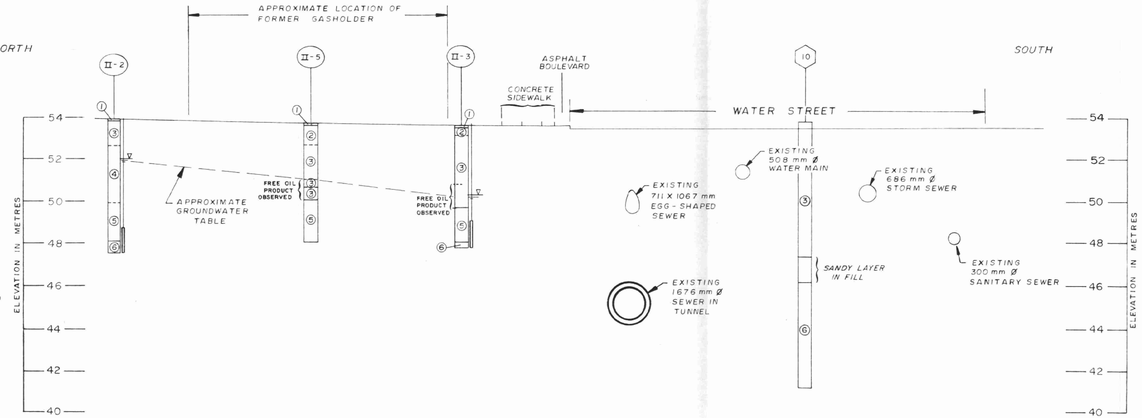
Drawn S.L
Chkd PAS
Appd

PLAN & SECTION ACROSS WATER STREET — FIGURE 15



PLAN

SCALE 1:240



SECTION G-G

SCALE HORIZ 1:120
VERT 1:120

LEGEND

- BOREHOLE LOCATION IN PLAN, PRESENT INVESTIGATION
- BOREHOLE LOCATION IN PLAN, PREVIOUS INVESTIGATION BY E.M. PETO ASSOCIATES
- II-2 BOREHOLE LOCATION IN ELEVATION
- WATER LEVEL IN ELEVATION (MAY 25, 1988)
- ② STRATA IDENTIFICATION (see below for description)
- WELL SCREEN IN ELEVATION

SOIL STRATIGRAPHY

①	**ASPHALT**
②	**FILL** - SAND WITH GRAVEL
③	**FILL** - GENERALLY SILTY CLAY WITH MISCELLANEOUS RUBBLE; SOME ORGANIC MATERIAL
④	**SILTY CLAY** (WEATHERED CRUST)
⑤	**SILTY CLAY**
⑥	**GLACIAL TILL**

SPECIAL NOTES (1) THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT

(2) FOR DETAILED SOIL DESCRIPTIONS AT BOREHOLE LOCATIONS, REFER TO RECORD OF BOREHOLE SHEETS

REFERENCES:

SEWER LOCATIONS: DRAWING 662-03 SANITARY SEWERS, STORM SEWERS AND WATER MAINS, WATER STREET FROM STA. 45+60 TO STA. 50+00, AUGUST 1974 PROVIDED BY CITY OF CORNWALL PUBLIC WORKS DEPARTMENT

GAS HOLDER LOCATION: FIRE INSURANCE PLAN, PUBLIC ARCHIVES CANADA, NMC-9381, 6/12, DATED 1916

Date JULY 26, 1988
Project 881-2705

Golder Associates

Drawn SL
Chkd JRS
Appd

APPENDIX A

COAL TAR WASTES DESCRIPTIONS
(ERT AND KOPPERS, 1984)

INTRODUCTION

This appendix present more details regarding the origin and general characteristics of wastes produced from the operation of the three most common types of manufactured gas plants: coke ovens (coal carbonization), water gas and oil gas. The information presented here has been exerpted from ERT and Koppers (1984) report on manufactured gas plants.

3.3 Waste and By-Product Characteristics

3.3.1 Types and Origins of Wastes

The major types of wastes and byproducts from manufactured gas plants include:

- Tars
- Sludges
- Tar liquors and ammonia liquor
- Spent iron oxide
- Ash, slag, clinkers
- Dust, off-grade coal and coke

The origin and general characteristics of each of these wastes types are summarized in section 3.3.2 for the three most common types of gas plants (coke ovens, water gas and oil gas). This is followed by more detailed descriptions of the most relevant wastes, namely tars and sludges (section 3.3.3) and spent oxide (section 3.3.4). A brief review of possible sources of trace metal contamination is also included (section 3.3.5).

The discussion of waste characteristics in this section is focused on production wastes generated during the active life of a plant. Such wastes were disposed on-site or off-site or in some combination of these two. In addition, wastes and other materials may also be present at a former plant site as a result of leaks, spills and normal handling of raw materials, products, by-products and wastes. Wastes and other materials may also be present in above-ground or underground process equipment, pipes or tanks, if such equipment remains at a former plant site. Finally, wastes and other materials may have been relocated on-site (spread or stock-piled) during plant demolition activities.

3.3.2 General Waste Characteristics

3.3.2.1 Coke Oven Plants

The waste streams listed below are likely precursors to waste materials possibly still residing in waste disposal areas of old coke plants operated in the manufactured gas era:

- Tar Sludge - This is a heavy, resinous material which ordinarily accumulated in collecting mains, decanter tanks, and other portions of the gas cleaning area. Most of these sludges would include a high level of solids. Although these sludges contain constituents of environmental concern (primarily polynuclear aromatic hydrocarbons), disposed tar sludges are not very mobile in the environment and are relatively stable. In fact, the presence of tar sludges at some disposal sites may have been somewhat beneficial in that the sludges can create relatively impervious barriers to percolation of other waste products through the disposal site.

- Clinkers, Ash, Coke - Since many of the manufactured gas plants were operated in conjunction with gas producers and water gas (blue gas) generators, much of the ash in the feed coal ended up as a waste product. This ash was generated in a variety of forms ranging from fine dust

to large clinkers. In addition, coke breeze and off-specification coke (known as "green" coke) may be present at disposal sites. These solid wastes are relatively stable, and much of their possible adverse environmental effect, such as dusting, would have been experienced shortly after they were formed. Any remaining impacts would largely be due to gradual leaching of trace metals.

- Fixed Salts of Cyanide, Ammonia, and Sulfur - During cleaning of coke oven gas, a variety of fixed salts of sulfur and nitrogen are formed and would have been disposed with some waste products. An example of such products is ammonium thiocyanate. These compounds were generated in small quantities compared to most waste products, and generation depended on the type of coal being used. These compounds may have been partially stabilized by other coke plant waste products. In addition, some of these compounds may have significantly decomposed over the last decades.

- Oil Sludges and Gas Condensates - These consist of aromatic-rich oils recovered and disposed during coke plant operation. They are not exceptionally volatile, but are characteristically odorous. It is possible that most of these sludges which could have escaped disposal sites may have already done so.

- Contaminated Liquors - Various tar and ammonia liquors may have also found their way to disposal sites. This probably would have been one of the more serious environmental problems at the time of disposal, but again it is likely that most of the adverse environmental impacts have already been experienced and any residues remaining over the last decades are relatively stabilized. Much of the liquor and ammonia may have evaporated or otherwise escaped the disposal site. In some cases these liquors may have been disposed in deep wells or abandoned mines.

- Sulfur Removal Wastes - As described in section 3.2.7, there were two basic types of processes used for removing H_2S from coke oven gas: iron oxide purifiers and liquid scrubbing systems. Iron oxide purifiers generated spent oxide material which was high in sulfur and cyanide. These wastes have a characteristic blue color from ferri/ferrocyanide complexes and were often disposed on-site. Liquid scrubbers based on adsorption/desorption or oxidation/reduction techniques came into use later in the gas plant era. Among the scrubbing solutions used were sodium carbonate (Na_2CO_3), sodium thioarsenate ($Na_4As_2S_5O_2$), and iron oxide suspensions in sodium carbonate. Various fixed salts purged from the scrubbing solution may have been disposed on-site (e.g., sodium thiocyanate, sodium thiosulfate).

- Miscellaneous Sludges - These include relatively small quantities generated during gas processing and water treatment. Examples include acid sludges, lime sludges, and caustic sludges. Some of these sludges may have provided stabilizing effects. For example, lime sludges would tend to hydraulically bind some waste products.

3.3.2.2 Water Gas

Since blue gas or water gas was often generated in conjunction with coke plant operation (with the feedstock to the gas generator being coke), many of the waste products were similar to those just cited for coke plant operation. However, these are the waste products more attributable to water gas generators per se:

- Tar Sludges - These were obtained from residual heavy hydrocarbons in the coke or from tars formed when oil was injected into the gas product. These materials would tend to be heavy and relatively stable.

- Ash and Clinkers - These originated from ash in the coke or coal feed. No serious adverse environmental problems are expected from these materials, although some leaching of trace elements may occur.

- Oxide Box Wastes- Water gas plants typically used iron oxide purifiers to remove H_2S from the product gas. Spent oxide material was often disposed on-site. It contains high concentrations of sulfur and cyanide and has a characteristic blue color from ferri/ferrocyanides.

- Polymers and Petroleum Sludges- Heavy fractions of the oil carburetted into the gas formed sludges which were recovered from the gas processing and distribution system. Some of the polymers were gums formed from nitrogen compounds. Their quantity was quite small, and their presence was a nuisance in that they tended to slowly plug appliance burners of customers.

- Emulsions and Contaminated Liquors- Various aqueous emulsions were formed when the blue gas was cooled and water and oil condensed. A relatively high amount of condensate could form because steam was injected into the gas generator and was also used in the carburetion step. It is like that many of these emulsions may have already escaped the disposal sites.

- Lamp Black- Carbon was formed when oil was gasified. Lamp black and other allotropic forms of carbon admixed with oil would have periodically been removed and disposed. Quantities are small in comparison to other wastes.

- Coke Fines - Fines were carried out of the generator and recovered for disposal during gas cooling and cleaning. Most of the fines were probably not exceptionally dusty once the gas was contacted with oil.

3.3.2.3 Oil Gas

The various oil gas plants were more prevalent in the West coast. Types of waste products are more difficult to establish since there are fewer published accounts of oil gas operations compared to coke plant operations. However, these are the expected types of wastes:

- Lamp Black and Free Carbon - Formed by decomposition or gasification of oil constituents under reducing conditions.

- Oxide Box Wastes - Oil gas plants typically used iron oxide purifiers for H_2S removal if high sulfur oils were used as feeds. Spent oxide material was often disposed on-site. It contains high concentrations of sulfur and cyanide and has a characteristic blue color from ferri/ferrocyanides.

- Sludges, Emulsions, and Contaminated Liquors - These were formed during cleaning of the gas, especially as excess water vapor was condensed.

- Tars, Pitch, Polymers - Various pyrolysis products were formed. These materials probably are similar to ethylene tar generated from naptha pyrolysis in present refineries. These tars would be more aliphatic than coal tars, yet relatively high in aromaticity since aromatic compounds are ordinarily refractory (i.e., inert) to most pyrolysis processes. In addition, these materials probably are high in asphaltenes.

- Ash - Very little ash is present in petroleum, but the recovered ash would be relatively high in vanadium and nickel compounds.

3.3.3 Tars and Sludges

The tars produced by gas manufacturing plants were valuable by-products throughout most of the gas plant era (see section 3.4).

Tars were commonly sold for further processing off-site or, in the case of some larger facilities - particularly coke oven plants, were processed on-site. It is important to understand the chemical characteristics of these tars even if they were not wastes per se. This is because byproduct tars may have been disposed as wastes at small, remote plants or in the early days of the manufactured gas industry (pre-1900) before tar refining became an established industry. In addition, the chemistry of byproduct tars provides an understanding of the characteristics of tarry sludges such as tank bottoms which were often disposed as wastes.

3.3.3.1 Chemical Characteristics

Tables 3-2 and 3-3 present comparative analyses of water gas, coke oven and oil gas tars. The key features to note from these tables are:

- water gas tars are lighter than coke oven tars (lower specific gravity and distillation residue), but all are denser than water;
- water gas tars contain no tar acids (primarily phenolics) while coke oven tars contain roughly 4% tar acids;
- oil gas and water gas tars are very similar for a given carburetting oil (Table 3-3);
- the heaviness of a water gas (or oil gas) tar depends on the heaviness of the oil used in the carburetor (Table 3-2); and
- all of the tars contain large amounts of high molecular weight residual material, with 40% to 75% of the tars boiling above 300°C (570°F) and 25% to 65% above 355°C (670°F).

The chemical constituents of coal tars are primarily polynuclear aromatic hydrocarbons, including heterocyclic compounds. This is illustrated by the analysis of a coke oven tar given in Table 3-4.

TABLE 3 -2

COMPARATIVE ANALYSES OF WATER-GAS AND COAL TARS[a]

Property	Water-gas tar No. 1 [b]	Water-gas tar No. 2 [c]	Low-temperature coal tar	Coke-oven coal tar	Horizontal-retort coal tar
Specific gravity at 15.5°C	1.061	1.125	1.105	1.196	1.240
Free carbon, per cent by weight	0.26	1.64	2.9	6.9	22.1
Tar acids, per cent by volume	0.00	0.00	31.7	4.2	4.4
Sulfonation residue, per cent by volume	8.3	5.2	1.9	Trace	0.7
Specific viscosity, Engler, 50 cc at 40°C	1.7	11.8	7.3	163.0	—
Float test, seconds at 50°C	—	—	—	26.0	24.0
Distillate (Engler) per cent by weight					
to 170°C	2.5	--	1.4	0.1	0.5
to 235°C	30.0	10.9	27.8	10.9	10.1
to 300°C	57.6	40.0	45.0	25.4	21.8
to 355°C	74.6	60.3	65.5	38.5	34.6
Specific gravity of distillate to 300°C	0.983	1.011	1.011	1.045	1.039
Specific gravity of distillate to 355°C	1.005	1.038	1.040	1.070	1.073
Specific gravity of fraction 300-355°C	1.080	1.093	1.090	1.121	1.135
Distillation residue at 300°C, per cent by weight	42.2	59.8	54.9	74.3	77.8
Specific gravity of 300° residue at 15.5°C	1.192	1.204	1.190	1.252	1.305
S.P. of 300° residue, C.W.	54°C	48°C	58.5°C	61.4°C	74.0°C
Free carbon in 300° residue, per cent by weight	1.5	6.1	6.2	12.1	33.0
Distillation residue at 355°C, per cent by weight	24.9	38.9	32.9	61.2	64.9
Specific gravity of 355° residue at 15.5°C	1.206	1.280	1.257	1.285	1.347
S.P. of 355° residue, C.A.	114°C	118.5°C	113°C	91.0°C	124°C
Free carbon in 355° residue, per cent by weight	18.5	20.8	25.2	18.5	41.8

Notes:

(a) Reproduced from Rhodes, 1966, pg. 41

(b) Gas oil used for carburetting.

(c) Bunker C fuel oil used for carburetting.

TABLE 3-3

COMPARATIVE ANALYSES OF A HEAVY WATER-GAS TAR AND AN OIL-GAS TAR[a,b]

Property	Water-gas tar	Oil-gas tar
Water, per cent by weight	0.2	1.1
Specific gravity at 25°/25°C	1.221	1.250
Float test at 32°C, seconds	123	100
Bitumen soluble in CS_2	85.6	81.5
Distillation, per cent by weight		
to 170°C	0.4	0.3
to 200°C	0.8	0.3
to 210°C	1.4	0.5
to 235°C	7.8	10.0
to 270°C	17.7	18.8
to 300°C	23.7	23.9
Distillation residue at 300°C, per cent by weight	75.7	75.5
S.P. (R & B) of distillation residue	70.5	74.8
Specific gravity at 38/38°C of distillate to 300°C	1.052	1.075
Sulfonation residue, per cent of distillate to 300°C	1.2	Trace
Naphthalene, per cent by weight	7.8	11.4
Oil removed to 110°C pitch, per cent by weight	30.0	29.4
Free carbon content of 110° pitch (benzol-toluol method) per cent by weight	36.8	39.0
Volatile material, per cent by weight of 110° pitch (1 gram heated for 2 min. at 950°C)	51.0	53.7
Ash, per cent by weight of 110°C pitch	0.11	0.11

Notes:

(a) Reproduced from Rhodes, 1966, pg. 43.

(b) Both tars made from No. 6 fuel oil.

TABLE 3-4

MAJOR CONSTITUENTS OF COAL TAR PER FISHER (1938) [a,b]
(PERCENTAGES BASED ON THE ORIGINAL TAR)

Coal tar			
Light oil, up to 200°C (392°C)	5.0		
Benzene	....	0.1	
Toluene	....	0.2	
Xylene	....	1.0	
Heavy solvent naphtha	....	1.5	
Middle oil, 200–250°C (392–482°F)	17.0		
Tar acids	....	2.5	
Phenol	....	....	0.7
Cresols	....	....	1.1
Xylenols	....	....	0.2
Higher tar acids	....	....	0.5
Tar bases	....	2.0	
Pyridine	....	....	0.1
Heavy bases	....	....	1.9
Naphthalene	....	10.9	
Unidentified	....	1.7	
Heavy oil, 250–300°C (482–572°F)	7.0		
Methylnaphthalenes	....	2.5	
Dimethylnaphthalenes	....	3.4	
Acenaphthene	....	1.4	
Unidentified	....	1.0	
Anthracene oil, 300–350°C (572–662°F)	9.0		
Fluorene	....	1.6	
Phenanthrene	....	4.0	
Anthracene	....	1.1	
Carbazole	....	1.1	
Unidentified	....	1.2	
Pitch	62.0		
Gas	....	2.0	
Heavy oil	....	21.8	
Red wax	....	7.0	
Carbon	....	32.0	

(a) Reproduced from Wilson & Wells, (1950, p. 374) and referenced from R.N. Shreve, "The Chemical Process Industries," p. 91, McGraw-Hill Book Company, Inc., New York, 1945.

(b) Also reported in Gas Engineers Handbook (1966, p. 3/17) and referenced as being obtained from C.H. Fisher, "Composition of Coal Tar and Light Oil", Bur. of Mines Bull. 412, Washington, D.C. 1938.

TABLE 3-5

REPORTED ANALYSES FOR SPECIFIC COMPONENTS IN COAL TAR (wt. pct.)

Animal Carcinogenicity(f)	Component	Formula	Structure	Boiling Point, °C(a)	Guerin et al 1978 (b)	Lijinsky 1963(c)	Bonnet 1961(d)	Fisher 1938(e)
+	Benzene	C_6H_6		80	-	-	-	0.1
-	Toluene	C_7H_8		111	-	-	-	0.2
-	Xylenes	C_8H_{10}		138-144	-	-	-	1.0
-	Phenol	C_6H_5OH		181	-	-	-	0.7
-	Cresols	C_7H_7OH		191-202	-	-	-	1.1
-	Xylenols	C_8H_9OH		201-227	-	-	-	0.2
-	Pyridine	C_5H_5N		115	-	-	-	0.1
-	Naphthalene	$C_{10}H_8$		218	-	-	-	10.9
-	Methylnaphthalenes	$C_{11}H_{10}$	-	241-245	-	-	-	2.5
-	Dimethylnaphthalenes	$C_{12}H_{12}$	-	262-269	-	-	-	3.4
-	Acenaphthene	$C_{12}H_{10}$		277	-	-	-	1.4
-	Carbazole	$C_{12}H_9N$		355	-	0.132/0.127	-	1.1
-	Fluorene	$C_{13}H_{10}$		297	-	-	-	1.6
-	Anthracene	$C_{14}H_{10}$		340	-	0.288/0.435	-	1.1
-	Phenanthrene	$C_{14}H_{10}$		340	-	1.36 /1.75	-	4.0
-	Fluoranthene	$C_{16}H_{10}$		393	-	1.77 /1.78	-	-
-	Pyrene	$C_{16}H_{10}$		394	-	0.795/1.05	-	-
+	Chrysene	$C_{18}H_{12}$		436	-	0.213/0.286	-	-
+	Benz(a)anthracene	$C_{18}H_{12}$		438	-	0.624/0.698	-	-
+	Benzo(j)fluoranthene	$C_{20}H_{12}$		~480	-	0.063/0.045	-	-
-	Benzo(k)fluoranthene	$C_{20}H_{12}$		480	-	0.108/0.107	-	-
+	Benzo(a)pyrene	$C_{20}H_{12}$		496	0.38±0.17	0.208/0.176	3.0	-
-	Benzo(e)pyrene	$C_{20}H_{12}$		493	-	0.185/0.188	-	-
-	Perylene	$C_{20}H_{12}$		460	-	0.070/0.076	-	-
+	Benzo(g,h,i)perylene	$C_{22}H_{12}$		500	-	0.123/0.189	-	-
-	Benzo(b)chrysene	$C_{22}H_{14}$		~500	-	0.093/0.080	-	-
+	Dibenz(a,h)anthracene	$C_{22}H_{14}$		-	-	0.030/0.023	-	-
					Totals	6.1/7.0	-	29.4

Notes:

(a) From (Anderson & Wu, 1963).

(b) No details given on analytical techniques or sample origin.

(c) Results are for "analysis of two different aliquots of the same material" (Lijinsky, et al, 1963, p-164). The sample was a "medicinal coal tar...obtained from Carzolo Drug and Chemical Co., Chicago" (Ibid, p. 953).

(d) No information given on sample origin.

(e) [illegible].

are polynuclear aromatic hydrocarbons (PAH), containing two or more fused benzene rings. Certain high molecular weight PAH - usually containing 4 to 6 fused rings - are carcinogenic and are of environmental concern primarily for this reason (see section 6.2). Table 3-5 summarizes analytical data for coal tars for some of these higher molecular weight PAH. The table (in conjunction with Table 6-1 in section 6.2.1) shows that coal tar can contain up to 1% or more of carcinogenic PAH.

Coke oven tar decanter sludge is a black, viscous, tarry material containing considerable coke oven dust and other particulate matter. Chemically, it is comprised almost entirely of polynuclear aromatic hydrocarbons (PAH) and heterocyclic PAH (PAH with one or more carbon atoms replaced by nitrogen, oxygen or sulfur atoms). Some of the hundreds of PAH compounds likely to be present are carcinogenic, and for this reason tar decanter sludge is a listed hazardous waste under RCRA (number K087).

Water gas and oil gas plant tar sludges were probably similar to coke oven tar decanter sludges in their origin and general characteristics. These tar sludges differ somewhat from coke oven tar chemically, however, since water gas and oil gas tars are almost wholly lacking in phenolics and oxygenated and nitrogenated organics compared to coke oven tar (Gas Engineers Handbook, 1966). Water gas and oil gas tar sludges are not listed RCRA wastes and would probably pass the RCRA hazardous waste tests. However, they would be expected to contain large quantities of PAH, a number of which are listed as RCRA Part 261 Appendix VIII hazardous constituents.

3.3.3.2 Production Rates

Tar yields from coke ovens and gas retorts are usually on the order of 10 gallons of dry tar per ton of dry coal carbonized (Wilson and Wells, 1950). For water gas plants, tar production was about 1 gallon per thousand cubic feet of gas, plus about 4 gal/MCF of oil (Gas Engineers Handbook, 1966). For oil gas plants, tar yields typically ranged from 2 to 4 gal/MCF, with yields increasing with heavier oil feeds.

Again, it must be noted that the tars from gas plants were usually sold or processed as valuable byproducts, so the yields quoted above do not represent waste generation rates. Waste generation rates are much more difficult to estimate. Van Osdell, et al. (1979) have estimated a production rate of roughly 25 gallons of coke oven tar decanter sludge per 1000 tons of coke production. This represents about 0.2% of a typical coke oven tar yield (assuming a 70% coke yield).

ERT's experience at one coke oven waste disposal site indicates a total generation rate for all sludges in the facility of no more than roughly 100 gallons per 1000 tons of coke. Based on these figures, sludge generation rates of from 0.1% to 1% of total tar production would appear to be a reasonable estimate.

3.3.4 Spent Oxide Waste

Water gas, oil gas and coke oven plants commonly used oxide boxes as a final gas purification step for removing H_2S from the manufactured gas. This was done by passing the gas through a bed of active, hydrated iron oxide, producing ferric sulfide. Spent oxide was regenerated by contact with air, producing reactivated iron oxide and sulfur. Cycles of fouling and regeneration were continued until the oxide eventually lost too much activity from accumulation of sulfur, fouling by traces of tar in the gas, and reaction of the iron with cyanide to produce ferrocyanides, which could not be regenerated and did not react with H_2S. At this point the spent oxide was discarded and replaced with fresh material.

Oxide boxes were usually long shallow containers with a large cross-sectional area. The boxes were often arranged to operate in series, with valving and manifolding to allow the order to be switched as the different boxes were deactivated and regenerated on different cycles. A box typically contained two or three layers of oxide, each being 3 to 6 feet deep. Iron oxide in the boxes was typically mixed with wood shavings, sawdust, corncobs, slag or similar materials to

provide better gas/solid contacting and to reduce pressure drop. The resulting spent oxide box material has a characteristic blue color due to the presence of ferrocyanide salts such as Prussian Blue.

A rough estimate of the amount of spent oxide box waste generated by manufactured gas plants can be obtained from operating data reported in the technical literature. Assuming a density of 20 to 25 pounds of oxide per cubic feet of bed material (Wilson and Wells, 1950) achieving theoretical H_2S adsorption capacity, 13 to 16 pounds of H_2S would be removed per cubic foot of oxide material. At this point the material would contain about 60% sulfur and be discarded. Total H_2S loadings over the life of a plant can be estimated from coal or oil feed rates or gas production rates, an assumed coal (or oil) sulfur content (assuming 100% conversion to H_2S) and the total operating life. Dividing this figure of total pounds H_2S production by 13 to 16 lb/ft^3 gives the total volume of spent oxide generated.

Spent oxide box wastes are high in sulfur and also contain significant amounts of various cyanides. As stated, the characteristic blue color of these wastes results from ferrocyanide salts such as Prussian Blue. Table 3-6 gives a very complete analysis of a spent oxide waste. This is probably representative of the complex chemistry of oxide box wastes, although filler materials other than peat, which is shown in Table 3-6, were often used. The various compounds listed in Table 3-6 on an elemental basis represent about 48% sulfur, 10% iron, and 3% cyanide, plus 18% moisture, 7% organic material, and 14% other elements. Sulfur, cyanide and heavy metals analyses for various weathered oxide wastes at British sites are given in Table 3-7. These analyses are in good general agreement with that in Table 3-6. Oxide box waste is not a listed RCRA hazardous waste, but might fail the RCRA reactivity test based on its cyanide and/or sulfide content.

3.3.5 Trace Metals

Elevated levels of certain trace metals may occur at former gas plant sites from a variety of sources. Table 3-8 summarizes potential sources of trace metals that are most likely to occur at such sites.

TABLE 3-6

AN ANALYSIS OF SPENT OXIDE
(Retyped from Hill, 1945, p. 1093)

	Percent
Free sulfur	44.70
Moisture	17.88
Ferric monohydrate	5.26
Ferrous monohydrate	6.25
Basic ferric sulfate	1.25
Ferric ammonium ferrocyanide	3.80
Ferrosoferric ammonium ferrocyanide	2.50
Ferric pyridic ferrocyanide	1.20
Organic matter peat fiber	4.68
Tar	1.21
Silica	1.05
Naphthalene	0.72
Pyridine sulfate	0.77
Ammonium sulfate	2.06
Calcium sulfate	0.12
Ferrous sulfate	0.02
Ammonium thiocyanate	1.30
Sulfur otherwise combined	1.33
Organic matter soluble in alkalies (humus)	1.54
Combined water and loss (by difference)	2.36
	100.00

TABLE 3-7

ANALYSES OF WEATHERED SPENT OXIDE WASTES
(Reproduced from Wilson and Stevens, 1981)

Species / Sample	Sulphur			Cyanides				Heavy Metals								pH
	Free S	$S^{=}$ (ppm)	$SO_4^{=}$	Total CN	SCN^- (ppm)	Free CN^- (ppm)	Complex Cyanides	Fe	Mn (ppm)	Zn (ppm)	Cr (ppm)	Cu (ppm)	Ni (ppm)	Pb (ppm)	Cd (ppm)	
Bog ore[1]	<0.1%	11	2.1%	280 ppm	54	3	750 ppm	25.2%	2,580	31	49	18	56	28	<2	3.5
Spent Oxides																
Beckton -																
weathered material[2]	45%	122	2.4%	3%	4000	800	4.6%	7.3%	2,310	39±4	23±4	21±4	23	20±15	2±2	5.6
weathered material[2]	54.7%	118	2.1%	3.4%	4300	780	5.3%	3%	2,050	22	29	13	36	20	<2	5.1
weathered nodule[3]	56.9%	42	2.8%	4%	1900	670	6.1%	7.9%	868	32	29	17	57	38	4	2.5
part-weathered oxide[3,4]	36.3%	63	1.4%	2.5%	4900	640	4.1%	5.7%	2,180	50	43	21	72	48	2	5.8
nodule	56.5%	195	2.2%	4.5%	5300	720	6.3%	3.4%	3,650	52	30	64	78	<15	2	5.5
Uxbridge	36.2%	68	2.2%	2.4%	5300	500	3.4%	9.4%	3,060	42	29	53	81	32	3	5.1

Notes:

(1) material remaining at Beckton gas works.
(2) powdery material dumped in the open about 5 years ago.
(3) consolidated material, found in hard lumps.
(4) material remaining in the purifier shed, exposed to air but under cover.

TABLE 3-8

POTENTIAL SOURCES OF TRACE METALS
THAT MAY BE ASSOCIATED WITH GAS PLANT WASTES

Element	Gasifier Ash Leachate[a]	Present in Bag Ore[b]	Heavy Fuel Oils	Catalysts and Corrosion Inhibitors[d]	Other	Comments
Aluminum	X					
Antimony	X					
Arsenic					X	Used in some sulfur recovery processes[c]. Perhaps used as an insecticide or herbicide[d].
Boron	X					
Cadmium	X				X	Perhaps minor uses in paint and fungicides[d].
Chromium	X	X			X	Corrosion inhibitor in gas holde sealing water[d].
Cobalt	X					
Copper	X	X		X	X	May have been used as a fungicide[d].
Iron	X	X				
Lead	X	X			X	Used in paint, caulking, pipework, roofing[d].
Manganese	X	X				

TABLE 3-8 (Cont'd)

Element	Gasifier Ash Leachate (a)	Present in Bag Ore (b)	Heavy Fuel Oils	Catalysts and Corrosion Inhibitors (d)	Other	Comments
Nickel	X	X	X	X		
Vanadium			X	X	X	Used in some sulfur recovery processes (c).
Zinc		X		X	X	Corrosion inhibitor in gas holder sealing water (d).

(a) Trace metals likely to be present in sufficient quantities in gasifier ash leachates that they could present a potential environmental hazard (U.S. EPA, 1978).
(b) Bog ore was commonly used as a source of iron oxide for purifier boxes. See also Table 3-7. (Wilson and Stevens, 1981).
(c) See section 3.2.7.
(d) From Wilson and Stevens (1981).

The primary sources are ash leachates and miscellaneous plant uses, including corrosion inhibitors, paint, caulking and pesticides. Table 3-9 shows the range of trace metal concentrations that have been measured in soil samples from eight different gas plant sites in Great Britain. Based on these two tables, the trace metals that are most liley to occur in high concentrations are arsenic, chromium, copper, iron, lead, nickel, and zinc.

3.4 History of Recycling Practices

3.4.1 Recovery and Use of Coal Tar

The quantity of coal tar that is generated during coal carbonization is influenced by the nature of the coal and the temperature at which the carbonization occurs. Some coals at low temperature yield about 16 gallons of tar per ton of coal while the same coal at high temperature yields about 9 gallons per ton.

In gas producers and coke ovens the tar generated will be carried out with the gas stream in both the vapor form and as a liquid mist. In order to avoid plugging of downstream piping and compressors, the tar must be removed.

The removal of the tar is accomplished by first cooling the gas in either direct water spray coolers or by indirect condensers. The gas can be further cleaned of tar contaminants by mechanical means or electrical precipitation.

In the very early days of producer gas plants, the tar that was removed was considered a nuisance and was probably disposed of in the easiest way possible (i.e., sludge pits, tar ponds, disposal wells, etc.). However, during the early 1900's as the tar distillation industry began to flourish, the tars produced in gas plants and coke ovens became an important raw material for the tar distillation industry.

TABLE 3-9

RANGE OF TRACE METAL CONCENTRATIONS
MEASURED IN SOIL SAMPLES FROM EIGHT BRITISH GAS PLANT SITES
(From Wilson and Stevens, 1981, p. 43)

Element	Number of Samples	Concentration Range (mg/kg)
Arsenic	208	<1 - 250
Boron	83	<1 - 8
Cadmium	209	<1 - 64
Chromium	145	2 - 250
Cobalt	26	4 - 32
Copper	208	2- 250
Lead	243	1 - 4,000
Mercury	124	<1 - 8
Molybdenum	26	1 - 32
Nickel	83	8 - 250
Zinc	125	2 - 1,000

APPENDIX B

RECORD OF BOREHOLE SHEETS
PREVIOUS INVESTIGATION

This appendix presents copies of borehole logs from previous geotechnical investigations in the area of the former gas plant site that were used to compile the geology in the area.

The borehole logs are presented in five parts as follows:

Part 1 Record of Boreholes 1 to 15
Golder Associates Project 742101, 1974
(Cornwall Civic Complex)

Part 2 Record of Boreholes 9, 10, 11, P-3
Golder Associates Projects 742079-1, 1974
and 752050, 1975
(Water Street Reconstruction)

Part 3 Record of Boreholes 1 to 16
St. Lawrence Testing Project 3C38, 1983
(Parks Canada Building)

Part 4 Record of Boreholes 1 to 5
St. Lawrence Testing Project 7C31, 1987
and SolRoc Consultants Inc.,
Project RA-36-8828 G, 1988
(Seniors Apartment, Amelia Street and First Street)

Part 5 Record of Boreholes 9, 10, 10A, 10B
E.M. Peto Associates Ltd. Project 6113, 1961
(Water Street Reconstruction)

APPENDIX B

RECORD OF BOREHOLE SHEETS, PREVIOUS INVESTIGATIONS

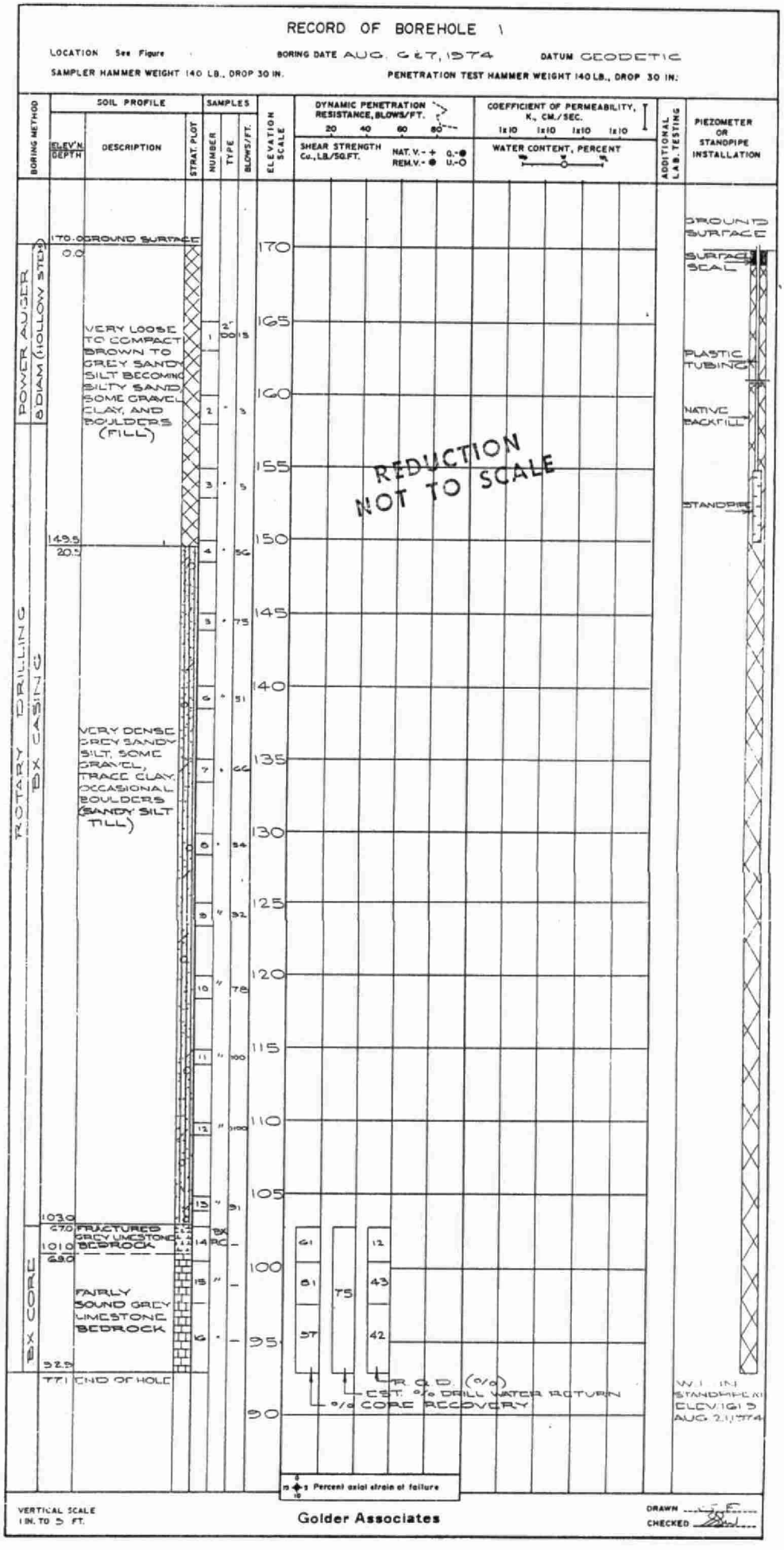
PART 1

RECORD OF BOREHOLES 1 TO 15

by

Golder Associates

Project 742101, 1974
(Cornwall Civic Complex)


RECORD OF BOREHOLE 1
LOCATION See Figure
BORING DATE AUG. 6 & 7, 1974
DATUM GEODETIC
SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.
PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.
BORING METHOD
SOIL PROFILE
ELEV'N DEPTH
DESCRIPTION
STRAT PLOT
SAMPLES
NUMBER
TYPE
BLOWS/FT.
ELEVATION SCALE
DYNAMIC PENETRATION RESISTANCE, BLOWS/FT.
20 40 60 80
SHEAR STRENGTH Cu., LB/SQ.FT.
NAT. V. - + Q.-●
REM.V. - ● U.-O
COEFFICIENT OF PERMEABILITY, K, CM./SEC.
1x10 1x10 1x10 1x10
WATER CONTENT, PERCENT
ADDITIONAL LAB. TESTING
PIEZOMETER OR STANDPIPE INSTALLATION
170.0 GROUND SURFACE
0.0
POWER AUGER
8" DIAM (HOLLOW STEM)
VERY LOOSE TO COMPACT BROWN TO GREY SANDY SILT BECOMING SILTY SAND, SOME GRAVEL, CLAY, AND BOULDERS (FILL)
149.5
20.5
ROTARY DRILLING
BX CASING
VERY DENSE GREY SANDY SILT, SOME GRAVEL, TRACE CLAY, OCCASIONAL BOULDERS (SANDY SILT TILL)
103.0
67.0
FRACTURED GREY LIMESTONE BEDROCK
101.0
69.0
BX CORE
FAIRLY SOUND GREY LIMESTONE BEDROCK
32.5
TT1 END OF HOLE
REDUCTION NOT TO SCALE
170
165
160
155
150
145
140
135
130
125
120
115
110
105
100
95
90
61
61
57
75
12
43
42
R.Q.D. (%)
CST. % DRILL WATER RETURN
% CORE RECOVERY
Percent axial strain at failure
GROUND SURFACE
SURFACE SEAL
PLASTIC TUBING
NATIVE BACKFILL
STANDPIPE
W.L. IN STANDPIPE ELEV. 161.5 AUG. 21, 1974
VERTICAL SCALE 1 IN. TO 5 FT.
Golder Associates
DRAWN
CHECKED

RECORD OF BOREHOLE 2

LOCATION See Figure 1 BORING DATE AUG. 5-12, 1974 DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD	SOIL PROFILE ELEV'N/DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS/FT.	ELEVATION SCALE
POWER AUGER 8" DIAM. (HOLLOW STEM)	167.0 0.0	GROUND SURFACE					170
		VERY LOOSE TO COMPACT BROWN TO GREY SANDY SILT, BECOMING SILTY SAND, SOME GRAVEL, CLAY AND BOULDERS, TRACE ORGANICS AT 21' DEPTH (FILL)		1	SS	4	165
				2	SS	8	160
				3	SS	1	155
	145.0			4	SS	30	150
	22.0	DENSE TO VERY DENSE GREY SANDY SILT, SOME GRAVEL, TRACE TO SOME CLAY OCCASIONAL BOULDERS (SANDY SILT TILL)		5	SS	30	145
				6	SS	35	140
				7	SS	88	135
				8	SS	100	130
				9	SS	>100	125
				10	SS	83	120
				11	SS	>100	115
	102.0			12	SS	>100	110
ROTARY DRILLING BX CORE	65.1	FAIRLY SOUND GREY LIMESTONE BEDROCK		13 BX RC		15	105
				14		1	100
	52.7						95
	74.5	END OF HOLE					

DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. (20, 40, 60, 80)

SHEAR STRENGTH Cu., LB/SQ.FT. NAT. V.- + REM.V.- ● O.-● U.-○

COEFFICIENT OF PERMEABILITY, K, CM./SEC. 1x10 1x10 1x10 1x10

WATER CONTENT, PERCENT (10, 40, 60, 80)

ADDITIONAL LAB. TESTING: MH, MH

PIEZOMETER OR STANDPIPE INSTALLATION: GROUND SURFACE; PLASTIC TUBING; NATIVE BACKFILL; STANDPIPE

REDUCTION NOT TO SCALE

82 75 33 R.Q.D. (%)

EST. % DRILL WATER RETURN

% CORE RECOVERY

W.L. IN STANDPIPE AT ELEV. 153.6 AUG. 21, 1974

Percent axial strain at failure

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

DRAWN GE CHECKED

Form G.A. - D - 1

Project No. 742101

RECORD OF BOREHOLE 3

LOCATION See Figure 1 BORING DATE AUG. 13, 1974 DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD	ELEV'N. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/FT.	ELEVATION SCALE
	170.0	GROUND SURFACE					170
POWER AUGER 8" DIAM (HOLLOW STEM)	0.0	VERY LOOSE BROWN TO GREY SANDY SILT WITH OCCASIONAL SILTY SAND ZONES, SOME GRAVEL, CLAY AND BOULDERS TRACE ORGANICS AT 20' DEPTH (FILL)		1	2" OD	3	165
				2	"	1	160
				3	"	"	155
	149.5			4	"	100	150
ROTARY DRILLING BX CORE	20.5	VERY DENSE GREY SANDY SILT, SOME GRAVEL, TRACE TO SOME CLAY OCCASIONAL BOULDERS (SANDY SILT TILL)		5	BX RC	-	145
				6	2" OD	52	140
	133.5			7	"	51	135
	36.5	END OF HOLE					130

DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. (20 40 60 80)

SHEAR STRENGTH Cu., LB./SQ.FT. NAT. V.- + Q.-● REM.V.- ● U.-O

COEFFICIENT OF PERMEABILITY, K, CM./SEC. (1x10 1x10 1x10 1x10)

WATER CONTENT, PERCENT (Wp W Wl)

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

GROUND SURFACE

PLASTIC TUBING

NATIVE BACKFILL

STANDPIPE

W.L. IN STANDPIPE AT ELEV 1662 AUG 21, 1974

REDUCTION NOT TO SCALE

15 (0 / 10) 5 Percent axial strain at failure

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

DRAWN GF

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Form G.A. - D - 1

Project No. 74210

RECORD OF BOREHOLE 4

LOCATION See Figure 1 . BORING DATE AUG. 14, 1974 DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD	SOIL PROFILE ELEV'N. / DEPTH	SOIL PROFILE DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/FT.	ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. (20 40 60 80) / SHEAR STRENGTH Cu., LB./SQ.FT. NAT. V. - + Q. - ● REM.V. - ● U. - ○	COEFFICIENT OF PERMEABILITY, K., CM./SEC. (1x10 1x10 1x10 1x10) / WATER CONTENT, PERCENT (Wp W WL)	ADDITIONAL L.A.B. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
POWER AUGER 8" DIAM (HOLLOW STEM)	169.1 GROUND SURFACE						170				GROUND SURFACE
	0.0	VERY LOOSE TO COMPACT BROWN TO GREY SANDY SILT, SOME GRAVEL, CLAY AND BOULDERS (FILL)		1	2" DO	16	165				PLASTIC TUBING
				2	"	K.	160				
				3		2	155				NATIVE BACKFILL
	148.0	VERY LOOSE DARK GREY SILTY SAND SOME ORGANICS (ALLUVIUM)									
	20.2 147.2			4		2	150				
	21.5	COMPACT TO VERY DENSE GREY SANDY SILT, SOME GRAVEL, TRACE TO SOME CLAY OCCASIONAL BOULDERS (SANDY SILT TILL)		5		19	145				
				6		32	140				
				7		54	135				
				8		>100	130				STANDPIPE
	122.1			9		44	125				
	47.0	END OF HOLE					120				W.L. IN STANDPIPE AT ELEV. 162.1 AUG 21, 1974

15 (0 / 10) 5 Percent axial strain at failure

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

DRAWN G.F.

CHECKED DSW

RECORD OF BOREHOLE 5

LOCATION See Figure 1 BORING DATE AUG. 15, 1974 DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD	SOIL PROFILE: ELEV'N / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT. PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/FT.
POWER AUGER 8" DIAM (HOLLOW STEM)	168.2 / 0.0	GROUND SURFACE				
		VERY LOOSE TO LOOSE BROWN TO GREY SANDY SILT, SOME GRAVEL, CLAY AND BOULDERS SOME ORGANICS AT 10 to 11' DEPTH (FILL)		1	2" DO	36
				2	"	3
				3	"	4
	146.2 / 22.0			4	"	5
		COMPACT TO VERY DENSE GREY BROWN TO GREY SANDY SILT SOME GRAVEL TRACE TO SOME CLAY, OCCASIONAL BOULDERS (SANDY SILT TILL)		5	"	30
				6	"	20
				7	"	61
				8	"	100
				9	"	41
	116.7 / 51.5	END OF HOLE		10	"	82

ELEVATION SCALE: 170, 165, 160, 155, 150, 145, 140, 135, 130, 125, 120, 115

DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. (20, 40, 60, 80)

SHEAR STRENGTH Cu., LB./SQ.FT. NAT. V.- + Q.-● REM.V.- ● U.-○

COEFFICIENT OF PERMEABILITY, K., CM./SEC. (1x10, 1x10, 1x10, 1x10)

WATER CONTENT, PERCENT

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

GROUND SURFACE

PLASTIC TUBING

NATIVE BACKFILL

STANDPIPE

W.L. IN STANDPIPE AT ELEV. 166.2 AUG 21, 1974

REDUCTION NOT TO SCALE

ε 0 ◆ 10 s Percent axial strain at failure

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

DRAWN GF

CHECKED

Form G.A. - D - 1

Project No. 74101

RECORD OF BOREHOLE 6

LOCATION See Figure 1 BORING DATE AUG. 16, 1974 DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD: POWER AUGER 8" DIAM. (HOLLOW STEM)

SOIL PROFILE ELEV'N / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS/FT.
169.6	GROUND SURFACE				
0.0	VERY LOOSE TO COMPACT GREY SANDY SILT, SOME GRAVEL, CLAY, AND BOULDERS (FILL)		1	2" DO	7
			2	"	13
			3	"	2
149.1 / 20.5	LOOSE DARK GREY SILTY SAND SOME ORGANICS (ALLUVIUM)		4	"	3
147.1 / 22.5	COMPACT TO VERY DENSE GREY BROWN TO GREY SANDY SILT SOME GRAVEL, TRACE TO SOME CLAY, OCCASIONAL BOULDERS (SANDY SILT TILL)		5	"	22
			6	"	50
			7	"	50
			8	"	39
			9	"	86
118.4 / 51.2	END OF HOLE		10	"	100

ELEVATION SCALE: 170, 165, 160, 155, 150, 145, 140, 135, 130, 125, 120

DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. (20, 40, 60, 80)

SHEAR STRENGTH Cu., LB./SQ.FT. NAT. V. - + Q. - ● REM. V. - ● U. - ○

COEFFICIENT OF PERMEABILITY, K, CM./SEC. (1x10, 1x10, 1x10, 1x10)

WATER CONTENT, PERCENT (Wp, W, WL)

ADDITIONAL LAB. TESTING: MH

PIEZOMETER OR STANDPIPE INSTALLATION: GROUND SURFACE; PLASTIC TUBING; NATIVE BACKFILL; STANDPIPE; W.L. IN STANDPIPE AT ELEV. 161.8 AUG 21, 1974

δ / 15 ◆ 5 / 10 Percent axial strain at failure

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

DRAWN GF

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Form G.A. - D - 1

Project No. 742-10

RECORD OF BOREHOLE 7

LOCATION See Figure 1 BORING DATE AUG. 19 & 20, 1974 DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD	ELEV'N. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/FT.	ELEVATION SCALE
POWER AUGER 8" DIAM (HOLLOW STEM)	170.3 / 0.0	GROUND SURFACE					170
		VERY LOOSE TO COMPACT BROWN TO DARK GREY SANDY SILT, SOME GRAVEL CLAY AND BOULDERS (FILL)		1	2" DO	11	165
				2	"	4	160
				3	"	4	155
	149.8 / 20.5						
	148.3 / 22.0	COMPACT DARK GREY SILTY SAND SOME ORGANICS (ALLUVIUM)		4	"	27	150
		COMPACT TO VERY DENSE GREY SANDY SILT, SOME GRAVEL TRACE TO SOME CLAY OCCASIONAL BOULDERS (SANDY SILT TILL)		5	"	23	145
				6	"	33	140
				7	"	31	135
	128.7 / 41.6	END OF HOLE		8	"	83	130
							125

DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. (20 40 60 80)

SHEAR STRENGTH Cu., LB/SQ.FT. NAT. V. - + Q. - ● REM. V. - ● U. - ○

COEFFICIENT OF PERMEABILITY, K, CM./SEC. (1x10 1x10 1x10 1x10)

WATER CONTENT, PERCENT

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

GROUND SURFACE

PLASTIC TUBING

NATIVE BACKFILL

STANDPIPE

W.L. IN STANDPIPE AT ELEV 166.8 AUG 21, 1974

REDUCTION NOT TO SCALE

0 / 15 / 10 / 5 Percent axial strain at failure

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

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Form G.A. - D - 1

Project No. 742101

RECORD OF BOREHOLE 8, 9, 10, 11 & 12

LOCATION See Figure 1 BORING DATE AUG. 20, 1974 DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD: POWER AUGER 8" DIAM (HOLLOW STEM)

SOIL PROFILE ELEV'N / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS/FT.	ELEVATION SCALE
B.H 8						
171.0	GROUND SURFACE					170
0.0	BROWN SANDY SILT, SOME GRAVEL & CLAY, OCCASIONAL BOULDERS MOIST AT 5' DEPTH (FILL)					
165.5						165
5.5	END OF HOLE					
BH 9						
170.1	GROUND SURFACE					170
0.0	GREY BROWN SANDY SILT, SOME GRAVEL & CLAY OCCASIONAL BOULDERS (FILL)					
165.1						165
5.0	END OF HOLE					
BH 10						
171.6	GROUND SURFACE					170
0.0	BROWN TO GREY BROWN SANDY SILT, SOME GRAVEL & CLAY (FILL)					
166.6						165
5.0	END OF HOLE					
BH 11						
171.9	GROUND SURFACE					170
0.0	BROWN SANDY SILT, SOME GRAVEL & CLAY (FILL)					
168.4						
3.5	GREY CLAYEY SILT SOME SAND & ORGANICS WET (FILL)					
166.9						165
5.0	END OF HOLE					
BH 12						
169.4	GROUND SURFACE					170
0.0	BROWN SANDY SILT SOME GRAVEL AND CLAY (FILL)					
166.9						
2.5						
166.9						
3.5	GREY BROWN SANDY SILT SOME GRAVEL & CLAY (FILL)					
163.9						165
5.5	END OF HOLE					
	DARK BROWN SANDY SILT, SOME GRAVEL TRACE ORGANICS (FILL)					

DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. 20 40 60 80

SHEAR STRENGTH Cu., LB/SQ.FT. NAT. V. - + Q. - ● REM. V. - ● U. - O

COEFFICIENT OF PERMEABILITY, K., CM./SEC. 1x10 1x10 1x10 1x10

WATER CONTENT, PERCENT

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

REDUCTION NOT TO SCALE

0 15 10 5 Percent axial strain at failure

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

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Form G.A. - D - 1

Project No. 74210

RECORD OF BOREHOLE 13, 14 & 15

LOCATION See Figure 1 BORING DATE AUG. 20, 1974 DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD: POWER AUGER 2" DIAM (HOLLOW STEM)

BH 13

ELEV'N. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FT.
171.6	GROUND SURFACE				
0.0	BROWN SANDY SILT SOME GRAVEL & CLAY (FILL)				
169.6					
2.0	WOOD (TIMBER)				
2.5	GREY CLAYEY SILT SOME WOOD AND ORGANICS (FILL)				
166.1					
5.5	END OF HOLE				

BH 14 NOT REDUCTION TO SCALE

ELEV'N. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FT.
170.8	GROUND SURFACE				
0.0	BROWN SANDY SILT, SOME GRAVEL AND CLAY NUMEROUS BOULDERS (FILL)				
165.3					
5.5	END OF HOLE				

BH 15

ELEV'N. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FT.
169.7	GROUND SURFACE				
0.0	BROWN SANDY SILT, SOME GRAVEL AND CLAY OCCASIONAL PIECES OF CONCRETE (FILL)				
164.2					
5.5	END OF HOLE				

ELEVATION SCALE: 170, 165, 170, 165, 170, 165, 160

DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. (20, 40, 60, 80)

SHEAR STRENGTH Cu., LB./SQ.FT. NAT. V. - + Q. -● REM. V. - ● U. -○

COEFFICIENT OF PERMEABILITY, K., CM./SEC. (1x10, 1x10, 1x10, 1x10)

WATER CONTENT, PERCENT (w_P, w, w_L)

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

ε 0 5 10 Percent axial strain at failure

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

DRAWN G.P.

CHECKED SAW

APPENDIX B

RECORD OF BOREHOLE SHEETS, PREVIOUS INVESTIGATIONS

PART 2

RECORD OF BOREHOLES 9, 10, 11, P-3

by

Golder Associates

Projects 752050, 1975
and 742079-1, 1974
(Water Street Reconstruction)

Form G.A.-O-1.

Project No. 752-052

RECORD OF BOREHOLE 9

LOCATION See Figure 1 BORING DATE MAY 20, 1975 DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD	ELEV'N. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES: NUMBER	TYPE	BLOWS/FT.	ELEVATION SCALE
	175.0	GROUND SURFACE					180
POWER AUGER 8" DIAM. (HOLLOW STEM)	0.0	STIFF GREY BROWN CLAYEY SILT, SOME SAND, TRACE GRAVEL (FILL)		1	2" OD	3	
				2	"	5	
	174.0						175
	5.0	LOOSE BROWN SANDY SILT, SOME GRAVEL (FILL)		3	"	15	
				4	"	4	
				5	"	6	
				6	"	6	170
				7	"	4	
	162.1						
	17.5	VERY STIFF GREY BROWN SILTY CLAY		8	"	2	165
	155.6						
	20.0	SILTY SAND TILL		9	"	100	160
	21.0	END OF HOLE					
							155

DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. (20 40 60 80)

SHEAR STRENGTH Cu., LB./SQ.FT. NAT. V. - + Q. -● REM.V. - ⊕ U. -○

COEFFICIENT OF PERMEABILITY, k, CM./SEC. (1x10 1x10 1x10 1x10)

WATER CONTENT, PERCENT W_P W W_L

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

W.L. IN OPEN BOREHOLE AT ELEV. 161.6, MAY 20, 1975

REDUCTION NOT TO SCALE

15 0 5 / 10 Percent axial strain at failure

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

DRAWN

CHECKED RBM

Form G.A.-D-1.

Project No. 75205.0

RECORD OF BOREHOLE 10

LOCATION See Figure 1 BORING DATE MAY 20, 1975 DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD	SOIL PROFILE: ELEV'N. / DEPTH	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: STRAT. PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/FT.	ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. (20 40 60 80) / SHEAR STRENGTH Cu., LB./SQ.FT. NAT. V. - + Q. -● REM.V. - ⊕ U. -O	COEFFICIENT OF PERMEABILITY, k, CM./SEC. (1x10 1x10 1x10 1x10) / WATER CONTENT, PERCENT Wp W Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
	179.2	GROUND SURFACE					180				
POWER AUGER 8" DIAM (HOLLOW STEM)	0.0	STIFF GREY BROWN CLAYEY SILT WITH SAND, TRACE GRAVEL (FILL)		1		3				MH	
	172.2			2		4	175			MH	
	7.0	VERY LOOSE BROWN SANDY SILT SOME GRAVEL (FILL)		3		4					
	163.7			4		2	170				
				5		1					
				6		2	165				
	15.5	VERY STIFF GREY BROWN SILTY CLAY		7		2					W.L. IN OPEN BOREHOLE AT ELEV. 165.2 MAY 20, 1975
	160.6										
	18.6	VERY DENSE GREY SILTY SAND, SOME CLAY AND GRAVEL (TILL)		8		20	160				
	15.7			9		100/0.1					
	21.5	END OF HOLE					155				

15 ◆ 5 Percent axial strain at failure

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

DRAWN GF

CHECKED RDK

Form G.A.-O-1.

Project No. 752050

RECORD OF BOREHOLE 11 & 12

LOCATION See Figure 1 BORING DATE MAY 20, 1975 DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD: POWER AUGER 8" DIAM (HOLLOW STEM)

BH 11

ELEV'N. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FT.
179.2	GROUND SURFACE				
0.0	STIFF GREY BROWN CLAYEY SILT WITH SAND, SOME GRAVEL TRACE WOOD AND BRICKS (FILL)		1	2" DO	2
			2	"	2
			3	"	2
			4	"	3
			5	"	3
			6	"	4
167.2					
12.0	END OF HOLE				

ELEVATION SCALE: 180, 175, 170, 165

DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. (20 40 60 80)

SHEAR STRENGTH Cu., LB./SQ.FT. NAT. V. - + Q. - ● REM.V. - ● U. - O

COEFFICIENT OF PERMEABILITY, k, CM./SEC. (1x10 1x10 1x10 1x10)

WATER CONTENT, PERCENT W_P W W_L (20 40 60 80)

ADDITIONAL LAB. TESTING:

PIEZOMETER OR STANDPIPE INSTALLATION:

REDUCTION NOT TO SCALE

BH 12

ELEV'N. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FT.
177.9	GROUND SURFACE				
0.0	STIFF GREY BROWN CLAYEY SILT WITH SAND, SOME GRAVEL (FILL)		1	2" DO	2
			2	"	3
			3	"	2
			4	"	3
			5	"	2
			6	"	4
167.4					
10.5	END OF HOLE				

ELEVATION SCALE: 180, 175, 170, 165

ADDITIONAL LAB. TESTING: MH

15 0 5 10 Percent axial strain at failure

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

DRAWN GF

CHECKED RAM

Form G.A. - D - 1

Project No. 742079-1

RECORD OF BOREHOLE P-3

BORING DATE JUNE 20, 1974

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD	ELEV'N / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/FT.	ELEVATION SCALE
	177.4	GROUND SURFACE					
8" POWER AUGER HOLLOW STEM	0.0	DARK BROWN SANDY SILT WITH GRAVEL AND BOULDERS (FILL)					175
	172.4						
	5.0	VERY STIFF GREY BROWN SILTY CLAY (WEATHERED CRUST)					170
	163.4						
	14.0	GREY SILTY CLAY					165
	159.9						
	17.5	VERY DENSE GREY SANDY SILT TILL		1	8"ø	60	160
	155.9						
	21.5	END OF HOLE					155

DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. (20 40 60 80)

SHEAR STRENGTH Cu., LB/SQ.FT. NAT. V. - + Q.-● REM.V.- ● U.-O

COEFFICIENT OF PERMEABILITY, K., CM./SEC. (1x10 1x10 1x10 1x10)

WATER CONTENT, PERCENT

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

LOCATION:
WATER STREET AT AMELIA STREET
32 FT. EAST OF CENTERLINE OF AMELIA STREET
26 FT. SOUTH OF CENTERLINE OF WATER STREET

REDUCTION NOT TO SCALE

PIPE & CAP
GROUND SURFACE
BENTONITE SEAL
SAND AND GRAVEL BACKFILL
BENTONITE SEAL
PIEZOMETER

WATER LEVEL IN PIEZOMETER AT ELEV. 164.4 JUNE 24, 1974

ε 0 15 10 5 Percent axial strain at failure

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

DRAWN D. Tidwell

CHECKED

APPENDIX B

RECORD OF BOREHOLE SHEETS, PREVIOUS INVESTIGATIONS

PART 3

RECORD OF BOREHOLES 1 TO 16

by

St. Lawrence Testing

Project 3C38, 1983
(Parks Canada Building)

OFF CE BOREHOLE RE ORD

APPENDIX

PROJECT NO. 2C73

CLIENT Public Works Canada — BOREHOLE NO. 1

LOCATION Horovitz Park - Water & Sydney Sts - Cornwall, Ont — CASING H.F. Auger

DATE OF BORING August 13/82 — DATE OF WL READING Aug. 13/82 — DATUM Geodetic

DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	CONDITION	TYPE	NUMBER	RECOVERY	N. VALUE	LABORATORY TESTS PERFORMED
0	54.56									
		Topsoil & Gravel Fill Mixture				SS	1	10	6	
	53.85									
1	.71	Silty Clay				SS	2	80	5	
		Grey-brown, moist, very stiff with trace of sand above 2.5 m. becoming grey, more moist and clayey, and stiff below 4.5 m.				SS	3	70	3	
2						ST	4	70		
3						ST	5	100		
4						ST	6	50		
5						ST	7	100		
6						ST	8	100		
						SS	9	100	3	
7						SS	10	100	4	
	46.85					SS	11	100	1	
	7.71	Silty Sand Till							28	
8		Grey, moist, dense to very dense with some gravel				SS	12	50	24	
						SS	13	60	27	
9						C			27	
	44.86					C			100 +	
10	9.70	Cone refusal at 9.70 m.								

LAB TEST RESULTS

WATER CONTENT & ATTERBERG LIMITS: WP — W — WL

DYNAMIC PENETRATION TEST BLOWS PER FOOT 0 20 40 60 80

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO 2C73

CLIENT Public Works Canada

BOREHOLE NO. 2

LOCATION Horovitz Park - Water & Sydney Sts. - Cornwall, Ont. BORING ~~H.F. Auger~~

DATE OF BORING Aug. 13/82 DATE OF WL READING Aug. 13/82 DATUM ~~Geodetic~~

SOIL PROFILE					SAMPLES						LAB TEST RESULTS
DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	CONDITION	TYPE	NUMBER	RECOVERY	N-VALUE	LABORATORY TESTS PERFORMED	WATER CONTENT & ATTERBERG LIMITS. WP W WL
	54.59										DYNAMIC PENETRATION TEST BLOWS PER FOOT. 0 20 40 60 PD
0		Topsoil & Cobble Fill Mixture									
	53.74										
1	.85	Silty Clay									
		Grey-brown, moist, very stiff becoming grey, more moist and clayey and stiff to firm below 4.0 m.				SS	1	80	5		
						ST	2	50			
2											
3						ST	3	90			
4						ST	4	90			
5						ST	5	90			
6						ST	6	100			
7						ST	7	100			
						ST	8	90			
8						ST	9	100			
9						ST	10	100			
						SS	11	100	1		
10						C			1		
						C			1		
						C			1		
						C			1		
11	43.46					C			2		
	11.13	Silty Sand Till				C			9		
		Grey, moist, dense to very dense with some gravel				C			16		
						C			20		

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 2C73

CLIENT Public Works Canada — BOREHOLE NO. 2

LOCATION Horovitz Park - Water & Sydney Sts.-Cornwall, Ont — CASING H.F. Auger

DATE OF BORING Aug. 13/82 — DATE OF WL READING Aug. 13/82 — DATUM Geodetic

DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	SAMPLES: CONDITION	TYPE	NUMBER	RECOVERY	N. VALUE	LABORATORY TESTS PERFORMED	LAB TEST RESULTS: WATER CONTENT & ATTERBERG LIMITS (WP, W, WL) / DYNAMIC PENETRATION TEST BLOWS PER FOOT (0, 20, 40, 60, PD)
13											
		Silty Sand Till				C			26		
						C			38		
						C			34		
	41.70					C			100 +		
13	12.89	Cone refusal at 12.89 metres									

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 2C73

CLIENT Public Works Canada

BOREHOLE NO. 3

LOCATION Horovitz Park-Water & Sydney Sts.-Cornwall, Ont.

CASING H.F. Auger

DATE OF BORING Aug. DATE OF WL READING Aug. DATUM Geodetic

DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	SAMPLES: CONDITION	TYPE	NUMBER	RECOVERY	N. VALUE	LABORATORY TESTS PERFORMED	LAB TEST RESULTS: WATER CONTENT & ATTERBERG LIMITS (Wp, W, WL) / DYNAMIC PENETRATION TEST BLOWS PER FOOT (0, 20, 40, 60, PD)
0	53.92										
	53.51	Topsoil & Sand Fill Mixture				SS	1	60	11		
	.41	Silty Clay Grey-brown, moist, very stiff, becoming grey, more moist and clayey, and stiff below 4.5 m.				SS	2	60	9		
1						SS	3	80	8		
2						SS	4	100	6		
3						ST	5	70			
						ST	6	100			
4						ST	7	100			
	49.01					ST	8	90			
5	4.91	Silty Sand Till Grey, moist, very dense with some gravel				SS	9	90	80		
6	47.67					SS	10	100	99		
	6.25	Termination of borehole at 6.25 m.									
7											

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO 2C73

BOREHOLE NO. 4

CLIENT Public Works Canada

LOCATION Horovitz Park-Water & Sydney Sts.-Cornwall, Ont.

CASING H.F. Auger

DATE OF BORING Aug. 12/82 DATE OF WL READING Aug. 13/82 DATUM Geodetic

DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	SAMPLES: CONDITION	TYPE	NUMBER	RECOVERY	N. VALUE	LABORATORY TESTS PERFORMED	LAB TEST RESULTS: WATER CONTENT & ATTERBERG LIMITS (WP, W, WL)
0	54.13										DYNAMIC PENETRATION TEST BLOWS PER FOOT (0, 20, 40, 60, PC)
		Topsoil & Sand Fill				SS	1	100	8		
	53.82 / .46	Concrete				SS	2	100	100	+	
1	.83	Cobble Fill									
	52.61 / 1.52	Silty Clay Grey-brown, moist, very stiff, becoming grey, more moist and clayey and stiff below 4.5 m.				SS	3	70	6		
2						ST	4	60			
3						ST	5	80			
						ST	6	80			
4						ST	7	80			
	48.95 / 5.18	Silty Sand Till Grey, moist, dense to very dense with some gravel				ST	8	90			
5						SS	9	100	4 14 22		
						SS	10	100	100+		
6						SS	11	100	100	+	
	47.18 / 6.95	Sampler refusal at 6.95 m.									
7											

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO 2C73

CLIENT Public Works Canada

BOREHOLE NO 5

LOCATION Horovitz Park-Water & Sydney Sts.-Cornwall, Ont.

CASING H.F. Auger

DATE OF BORING Aug. 12/82 DATE OF WL READING Aug. 13/82

DATUM Geodetic

DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	CONDITION	TYPE	NUMBER	RECOVERY	N. VALUE	LABORATORY TESTS PERFORMED
0	54.04									
	53.84	Topsoil								
	.20	Clayey Silt				SS	1	60	7	
		Brown, moist, loose								
	53.13					SS	2	40	7	
1	.91	Silty Clay								
		Grey-brown, moist, very stiff, becoming grey, more moist and clayey below 4.0 m.				SS	3	40	8	
2						ST	4	50		
						ST	5	60		
3						ST	6	100		
						ST	7	90		
4						ST	8	50		
5						SS	9	100	4	
						SS	10	100	3	
6	47.94									
	6.10	Silty Sand Till				SS	11	100	59	
		Grey, moist, dense to very dense with some gravel				SS	12	100	45	
7										
8						SS	13	0	17	
						C			4	
						C			6	
9						C			20	
						C			35	
10	43.98					C			30	
	10.06	Termination of cone penetration at 10.06 m.				C			90	

LAB TEST RESULTS

WATER CONTENT & ATTERBERG LIMITS: WP W WL

DYNAMIC PENETRATION TEST BLOWS PER FOOT ... 0 20 40 60 80

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 2C73

CLIENT Public Works Canada — BOREHOLE NO. 6

LOCATION Horovitz Park-Water & Sydney Sts.-Cornwall, Ont. — CASING Cone

DATE OF BORING Aug. 13/82 — DATE OF WL READING — DATUM

SOIL PROFILE					SAMPLES						LAB TEST RESULTS
DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	CONDITION	TYPE	NUMBER	RECOVERY	N. VALUE	LABORATORY TESTS PERFORMED	WATER CONTENT & ATTERBERG LIMITS: WP W WL
	53.98										DYNAMIC PENETRATION TEST BLOWS PER FOOT 0 20 40 60 80
0		Silty Clay				C			4		
						C			6		
						C			4		
1						C			5		
						C			5		
2						C			5		
						C			4		
						C			4		
3						C			5		
						C			6		
						C			8		
4						C			8		
						C			9		
						C			9		
5						C			9		
						C			9		
						C			10		
						C			11		
6						C			12		
	47.61					C			14		
	6.37	Silty Sand Till				C			13		
		Termination of cone penetration at 6.71 m.				C			70		
7											

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 2C73

CLIENT Public Works Canada

BOREHOLE NO 7

LOCATION Horovitz Park-Water & Sydney Sts.-Cornwall, Ont.

CASING Cone

DATE OF BORING Aug. 13/82

DATE OF WL READING

DATUM

DEPTH	ELEVATION DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	SAMPLES: CONDITION	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: RECOVERY	SAMPLES: N. VALUE	LABORATORY TESTS PERFORMED	LAB TEST RESULTS: WATER CONTENT & ATTERBERG LIMITS (WP, W, WL)	LAB TEST RESULTS: DYNAMIC PENETRATION TEST BLOWS PER FOOT (0, 20, 40, 60, PD)
0	54.20											
		Silty Clay				C			6			
						C			8			
1						C			4			
						C			3			
						C			4			
2						C			5			
						C			6			
						C			7			
3						C			10			
						C			12			
						C			12			
4						C			11			
						C			10			
						C			11			
						C			10			
5						C			10			
						C			11			
						C			12			
6						C			13			
						C			11			
						C			11			
7						C			12			
						C			11			
						C			10			
8						C			11			
						C			13			
						C			13			
9						C			15			
						C			15			
						C			13			
						C			12			
10	44.26					C			12			
	9.94	Silty Sand Till				C			30			
						C			42			
		Termination of cone penetration at 10.36 m.										

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 2C73

CLIENT Public Works Canada — BOREHOLE NO. 8

LOCATION Horovitz Park-Water & Sydney Sts.-Cornwall, Ont. — CASING Cone

DATE OF BORING Aug. 13/82 — DATE OF WL READING — DATUM

SOIL PROFILE					SAMPLES					LABORATORY TESTS PERFORMED	LAB TEST RESULTS
DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	CONDITION	TYPE	NUMBER	RECOVERY	N-VALUE		WATER CONTENT & ATTERBERG LIMITS. WP — W — WL
0	53.89										DYNAMIC PENETRATION TEST BLOWS PER FOOT. 0 20 40 60 80
		Silty Clay				C			6		
						C			5		
						C			3		
1						C			2		
						C			4		
						C			6		
2						C			9		
						C			11		
						C			13		
3						C			15		
						C			17		
						C			18		
4						C			18		
						C			19		
						C			21		
						C			20		
5						C			20		
	48.34										
	5.55	Silty Sand Till				C			20		
						C			42		
6		Termination of cone penetration at 6.10 m.				C			50		

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. OC38

BOREHOLE NO. 9

CLIENT Westeinde Const. Ltd.

LOCATION Horovitz Park - Water & Sydney Sts., Cornwall

CASING H.F. Auger

DATE OF BORING Apr. 25/83 DATE OF WL READING Apr. 27/83 DATUM Geodetic

DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	SAMPLES: CONDITION	TYPE	NUMBER	RECOVERY	N. VALUE	LABORATORY TESTS PERFORMED	LAB TEST RESULTS: WATER CONTENT & ATTERBERG LIMITS (WP, W, WL)
0	54.54										DYNAMIC PENETRATION TEST BLOWS PER FOOT (0, 20, 40, 60, PD)
		Topsoil & Sand Fil Mixture				SS	1	30	4		
	53.73										
1	0.81	Silty Clay Grey-brown, moist very stiff, becoming grey, more moist, clayey and stiff below 4.1 m.		▼		SS	2	50	4		
2											
3						ST	3	90			
4						ST	4	100			
5						ST	5	100			
6						ST	6	90			
7						ST	7	40			
	46.62										
8	7.92	Silty Sand Till									
9											

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 3C38

CLIENT Westeinde Const. Ltd. BOREHOLE NO. 10

LOCATION Horovitz Park - Water & Sydney Sts., Cornwall CASING H.F. Auger

DATE OF BORING Apr. 26/83 DATE OF WL READING Apr. 27/83 DATUM Geodetic

DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	SAMPLES: CONDITION	TYPE	NUMBER	RECOVERY	N. VALUE	LABORATORY TESTS PERFORMED	LAB TEST RESULTS: WATER CONTENT & ATTERBERG LIMITS (WP, W, WL) / DYNAMIC PENETRATION TEST BLOWS PER FOOT (0, 20, 40, 60, PD)
0	54.81										
		Topsoil & Gravel Fill Mixture				SS	1	60	4		
1	53.90					SS	2	80	4		
	0.91	Silty Clay Grey-brown, moist, very stiff, becoming grey, more moist, clayey and stiff below 4.5 m.		▼		ST	3	90			
2											
3						ST	4	100			
4						ST	5	100			
						ST	6	100			
5						ST	7	100			
6						ST	8	100			
7											
8	46.73										
	8.08	Silty Sand Till									
9											

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 3C38

CLIENT Westeinde Const. Ltd. BOREHOLE NO. 11

LOCATION Horovitz Park, Water & Sydney Sts., Cornwall CASING H.S. Auger

DATE OF BORING Apr. 26/83 DATE OF WL READING Apr. 27/83 DATUM Geodetic

SOIL PROFILE					SAMPLES						LAB TEST RESULTS
DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	CONDITION	TYPE	NUMBER	RECOVERY	N-VALUE	LABORATORY TESTS PERFORMED	WATER CONTENT & ATTERBERG LIMITS. WP — W — WL; DYNAMIC PENETRATION TEST BLOWS PER FOOT 0 20 40 60 80
0	54.94										
		Topsoil & Gravel Fill Mixture				SS	1	40	6		
1	53.97										
	0.97	Silty Clay									
		Grey-brown, moist, very stiff, becoming grey, more moist, clayey and stiff below 4.6 m.				ST	2	90			
2						ST	3	100			
3						ST	4	90			
4						ST	5	100			
5						ST	6	100			
						ST	7	100			
6						ST	8	100			
7						ST	9	90			
8						ST	10	100			
9											
10	45.03										
	9.91	Silty Sand Till									

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 3C38

CLIENT Westeinde Const. Ltd. BOREHOLE NO. 12

LOCATION Horovitz Park, Water & Sydney Sts., Cornwall CASING H.F. Auger

DATE OF BORING Apr. 26/83 DATE OF WL READING Apr. 27/83 DATUM Geodetic

SOIL PROFILE					SAMPLES						LAB TEST RESULTS
DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	CONDITION	TYPE	NUMBER	RECOVERY	N. VALUE	LABORATORY TESTS PERFORMED	WATER CONTENT & ATTERBERG LIMITS. WP W WL / DYNAMIC PENETRATION TEST BLOWS PER FOOT 0 20 40 60 PD
0	54.97										
		Topsoil & Sand Fill Mixture				SS	1	40	5		
	54.11										
1	0.86	Silty Clay Grey-brown, moist very stiff, becoming grey, more moist, clayey and stiff below 4.4 m.		▼		ST	2	100			
2						ST	3	90			
3						ST	4	90			
4						ST	5	90			
						ST	6	100			
5						ST	7	100			
6						ST	8	90			
7						ST	9	100			
8						ST	10	100			
9											
10	44.45										
	10.52	Silty Sand Till									
11											

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 3C38

CLIENT Westeinde Const. Ltd. BOREHOLE NO. 13

LOCATION Horovitz Park, Water & Sydneys St., Cornwall CASING H.F. Auger

DATE OF BORING Apr. 27/83 DATE OF WL READING Apr. 27/83 DATUM Geodetic

SOIL PROFILE					SAMPLES					LABORATORY TESTS PERFORMED	LAB TEST RESULTS
DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	CONDITION	TYPE	NUMBER	RECOVERY	N-VALUE		WATER CONTENT & ATTERBERG LIMITS. WP W WL
0	54.72										DYNAMIC PENETRATION TEST BLOWS PER FOOT. 0 20 40 60 80
	54.21	Topsoil & Sand Fill Mixture									
	0.51	Silty Clay Grey-brown, moist, very stiff, becoming grey, more moist, clayey and stiff below 4.5 m.		▼							
1											
2											
3						ST	1	100			
4											
5						ST	2	100			
6											
7						ST	3	100			
	46.80										
8	7.92	Silty Sand Till									
9											
10											

OF. ICE BOREHOLE R CORD

APPENDIX

PROJECT NO 3C38

CLIENT Westeinde Const. Ltd. BOREHOLE NO. 14

LOCATION Horovitz Park, Water & Sydney Sts., Cornwall CASING H.F. Auger

DATE OF BORING Apr. 26/83 DATE OF WL READING Apr. 27/83 DATUM Geodetic

DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	SAMPLES: CONDITION	TYPE	NUMBER	RECOVERY	N. VALUE	LABORATORY TESTS PERFORMED	LAB TEST RESULTS: WATER CONTENT & ATTERBERG LIMITS (WP, W, WL) / DYNAMIC PENETRATION TEST BLOWS PER FOOT (0, 20, 40, 60)
0	54.71										
		Topsoil & Gravel Fill Mixture									
	54.00										
1	0.71	Silty Clay Grey-brown, moist very stiff, becoming grey, more moist, clayey and stiff below 4.6 m.		▼							
2											
3						ST	1	100			
4											
5						ST	2	100			
6											
7						ST	3	100			
8						ST	4	90			
	45.82										
9	8.89	Sandy Silt Till									
10											

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO. 3C38
BOREHOLE NO. 15
CASING H.F. Auger
DATUM Geodetic

CLIENT Westeinde Const. Ltd.
LOCATION Horovitz Park, Water & Sydney Sts., Cornwall
DATE OF BORING Apr. 26/83 DATE OF WL READING Apr. 27/83

DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	SAMPLES: CONDITION	TYPE	NUMBER	RECOVERY	N. VALUE	LABORATORY TESTS PERFORMED	LAB TEST RESULTS: WATER CONTENT & ATTERBERG LIMITS (WP, W, WL)	DYNAMIC PENETRATION TEST BLOWS PER FOOT (0, 20, 40, 60 ft)
0	54.81											
		Topsoil & Gravel Fill Mixture										
	54.15											
1	0.66	Silty Clay										
		Grey-brown, moist, very stiff, becoming grey, more moist, clayey and stiff below 3.9 m.		▼		ST	1	100				
2												
3						ST	2	100				
4												
5						ST	3	100				
6												
7						ST	4	100				
8						ST	5	100				
9												
	45.21											
10	9.60	Silty Sand Till										

OFFICE BOREHOLE RECORD

APPENDIX

PROJECT NO 3C38

BOREHOLE NO. 16

CLIENT Westeinde Const. Ltd.

LOCATION Horovitz Park, Water & Sydney Sts., Cornwall

CASING H.F. Auger

DATE OF BORING Apr. 27/83 DATE OF WL READING Apr. 27/83 DATUM Geodetic

DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	SAMPLES: CONDITION	TYPE	NUMBER	RECOVERY	N. VALUE	LABORATORY TESTS PERFORMED	LAB TEST RESULTS: WATER CONTENT & ATTERBERG LIMITS (WP, W, WL) / DYNAMIC PENETRATION TEST BLOWS PER FOOT (0, 20, 40, 60, PD)
0	54.35										
		Topsoil & Sand Fill Mixture									
	53.79										
1	0.56	Silty Clay Grey-brown, moist very stiff, becoming grey, more moist, clayey and stiff below 4.5 m.		▼							
2											
3						ST	1	100			
4											
5						ST	2	100			
6						ST	3	100			
7						ST	4	90			
	46.89										
	7.46	Silty Sand Till									
8											
9											

APPENDIX B

RECORD OF BOREHOLE SHEETS, PREVIOUS INVESTIGATIONS

PART 4

RECORD OF BOREHOLES 1 TO 5

BY

St. Lawrence Testing, Project 7C31, 1987

and

SolRoc Consultants Inc., Project RA-36-8828G, 1988
(Proposed Seniors Apartment, Amelia Street at First Street)

OFFICE BOREHOLE RECORD

PROJECT NO. 7031

CLIENT Roy & Pico Inc. BOREHOLE NO. 1

LOCATION First & Amelia Sts - Cornwall, Ont. CASING H.S. Auger

DATE OF BORING April 11/87 DATE OF WL READING April 11/87 DATUM Geodetic

DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	SAMPLES: CONDITION	TYPE	NUMBER	RECOVERY	N-VALUE	LABORATORY TESTS PERFORMED	LAB TEST RESULTS: WATER CONTENT & ATTERBERG LIMITS (Wp, W, Wl)	DYNAMIC PENETRATION TEST BLOWS PER FOOT: 0, 20, 40, 60
0	183.4											
0		3" Gravel Fill Misc. Fill Brick & sandy silt fill to 4.6 ft. Concrete slab to 4.9 ft.										
4	178.5											
6	4.9	Silty Clay Grey, wet, firm to 12 ft. becoming soft to very soft below 12 ft.				SS	1	80	2			
10				15.0		ST	2	90				
20						ST	3	100				
30						ST	4	100				
	146.4					SS	5	100	1			
40	37.0	Sandy Silt Till Grey, moist, loose becoming compact below 42 ft. and dense below 45 ft.				SS C C C	6	40	41 23 34 42			
50	131.4					C C			64 85			
55	52.0	Termination of borehole										

CITY OF CORNWALL BOREHOLE RECORD

Project No. 7031
Client: Roy & Pico Inc.
Borehole No. 2
Location: First & Amelia Sts. - Cornwall, Ont.
Drilling: H.F. Auger
Date of Boring: April 11/87 Date of WL Reading: April 11/87 Datum: Geodetic

DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	SAMPLES: CONDITION	TYPE	NUMBER	RECOVERY	N-VALUE	LABORATORY TESTS PERFORMED	LAB TEST RESULTS: WATER CONTENT & ATTERBERG LIMITS Wp W WL
0	182.6										DYNAMIC PENETRATION TEST BLOWS PER 1 FOOT: 0 20 40 60
	55.66	Misc. Fill Brick & sandy silt fill with some organics present (bark)									
5						SS	1	20	9		
	175.1										
	7.5 2.29	Silty Clay Grey, wet, firm to 10 ft. becoming soft to very soft below 10 ft.		8.8							
10											
15						ST	2	100			
					C				.3		
					C				.3		
20					C				.3		
					C				.3		
					C				.3		
25					C				.3		
					C				1		
					C				1		
					C				2		
30					C				2		
					C				3		
					C				3		
					C				2		
					C				3		
35	146.6				C				4		
					C				3		
	36.0 10.97	Sandy Silt Till Grey, moist, compact			C				5		
	142.8				C				18		
40	39.8	Cone Refusal			C				39		
	12.13				C				25		
					C				100+		

C FICE BOREHOLE ECORD

PROJECT NO. 7031

CLIENT Roy & Pico Inc. BOREHOLE NO. 3

LOCATION First & Amelia Sts. - Cornwall, Ont. METHOD H.F. Auger

DATE OF BORING April 11/87 DATE OF WL READING April 11/87 DATUM Geodeti

DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRATA PLOT	WATER CONDITIONS	SAMPLES: CONDITION	TYPE	NUMBER	RECOVERY	N-VALUE	LABORATORY TESTS PERFORMED	LAB TEST RESULTS: WATER CONTENT & ATTERBERG LIMITS (Wp, W, WL)	DYNAMIC PENETRATION TEST BLOWS PER 0.3m: 0 20 40 60
0	180.9											
	55.14	Misc. Fill Brown, moist, sandy silt fill										
2	178.4											
	2.5 0.76	Misc. Fill Dark brown, moist, sandy silt with some organics (bark) present. Bark not noted below 6 ft. Fill becomes wet below 8 ft.										
4												
6				7.1 ▽								
8												
10						ST	1	80				
12						SS	2	10	1			
14	166.9											
	14.0 4.27	Termination of borehole in wet fill										

OFFICE BOREHOLE RECORD

PROJECT NO. 7C31

CLIENT Roy & Pico Inc. BOREHOLE NO. 4

LOCATION First & Amelia Sts., Cornwall, Ont. DRILLED H.F. Auger

DATE OF BORING April 11/87 DATE OF WL READING April 11/87 DATUM Geodetic

DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRATA PLOT	WATER CONDITIONS	SAMPLES: CONDITION	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: RECOVERY	SAMPLES: N VALUE	LABORATORY TESTS PERFORMED	LAB / TEST RESULTS: WATER CONTENT & ATTERBERG LIMITS W_P W W_L	DYNAMIC PENETRATION TEST BLOWS PER FOOT 0 20 40 60
0	178.3	54.34 Topsoil										
2	176.5											
	1.8	Misc. Fill										
	0.55	Grey-brown, moist, sandy silt and cinders, becoming wet below 7 ft.										
6				6.7 ▽								
8												
10	167.3				X	SS	1	70	3			
	11.0	Silty Clay			C				1			
	3.33	Grey, wet, firm becoming soft to very soft below 13 ft.			C				.5			
15					C				.5			
					C				1			
					C				1			
20					C				1			
					C				1			
					C				1			
25					C				2			
					C				2			
					C				2			
30					C				2			
					C				3			
					C				2			
35					C				3			
					C				3			
					C				2			
40	138.8				C				3			
	39.5	Sandy Silt Till			C				4			
	12.04	Grey, moist, loose			C				5			
					C				5			
					C				7			
					C				4			
					C				3			

CITICE BOREHOLE RECORD

Roy & Pico Inc.
First & Amelia Sts. - Cornwall, Ont.
DATE OF BORING April 11/87 DATE OF WELL INSTALLATION April 11/87
7C31
5
H.F. Auger
Geodetic

DEPTH	ELEVATION / DEPTH	SOIL DESCRIPTION	STRAT. PLOT	WATER CONDITIONS	SAMPLES: CONDITION	TYPE	NUMBER	RECOVERY	N VALUE	LABORATORY TESTS PERFORMED	LAB TEST RESULTS: WATER CONTENT & ATTERBERG LIMITS (Wp, W, WL)
0	187.7										DYNAMIC PENETRATION TEST BLOWS PER 1 FOOT (0, 20, 40)
	57.21 / 187.1	Topsoil									
2	0.6 / 0.18	Sand Yellow, moist, loose with silt									
4											
6											
8	54.5 / 178.9										
10	8.8 / 2.68	Silty Clay Grey, wet, soft to very soft			X	SS	1	80	1		
20											
						ST	2	100			
30											
40											
	43.3 / 142.2										
45	45.5 / 13.86 / 42.06 / 138.0	Sandy Silt Till Grey, moist, dense			C				1		
					C				7		
					C				26		
					C				65		
50	49.7 / 15.15	Cone refusal			C				100+		

REFERENCE: 8828-G-1

ANNEXE(E) NO. 1

SOLROC CONSULTANTS INC.

RAPPORT DE FORAGE

BOREHOLE REPORT

CLIENT: Roy & Pico Inc.

PROJ.: Proposed condominium complex

SITE: Amelia and First Sts., Cornwall, Ontario

TEST: Location: See drawing No. 8828 G-1

PREP.: D.D. SUPER.: A.B.

FORAGE NO. / BOREHOLE NO. A

DATE: COMM. February 24, 1988.

DATE: FIN. February 26, 1988.

TUB. / CAS.

PROFONDEUR DEPTH PIEDS FEET	MM	ELEVATION FEET	DESCRIPTION SURFACE DU SOL GROUND SURFACE	N.E. W.L.	SYMB	ECHANTILLONS SAMPLES TYPE/NO	REC %	RESISTANCE AU CISAILLEMENT ET A LA PENETRATION STRENGTH & PENETRATION RESISTANCE KPa 20 40 60 80 'N'	PROF. DEPTH Pi. Ft.	MM
0	0	179.5	Fill: Brown organic topsoil and brown sand with traces of clay, pieces of glas and porcelaine.			SS1	5			
	1 000	54.71				SS2	55			
5	2 000									
10	3 000	3.72								
12.2		167.3								
	4 000	50.99	Grey clay with traces of silt and traces of organics from 15.0' to 22.0'.			ST3	100			
15	5 000					ST4	100			
20	6 000					ST5	100			
	7 000									
25	8 000					ST6	100			
	9 000									

continued

ANNEXE NO. 2

FORAGE NO. / BOREHOLE NO. (A) Cont'd.

PROFONDEUR DEPTH PIEDS FEET	MM	ELEVATION FEET	DESCRIPTION SURFACE DU SOL GROUND SURFACE	N.E. W.L.	SYMB.	ECHANTILLONS SAMPLES TYPE/NO	REC %	RESISTANCE AU CISAILLEMENT ET A LA PENETRATION STRENGTH & PENETRATION RESISTANCE KPa 20 40 60 80 'N'	PROF. DEPTH Pi. Ft.	MM
30	10000	149.5	Grey clay with traces of silt.			ST7	100			
35	11000					ST8	0			
39.0	12000	11.89 140.5								
40		42.82	Very dense grey sandy silt till with some gravel and some cobbles from 50.0' to 56.0'.			SS9	100	50 Blows/1" Refusal		
45	13000 14000					SS10	0	50 Blows/0" Refusal		
50	15000 16000					RC11	4			
55	17000									
60	18000 19000					SS12	100	50 Blows/0" Refusal		

FORAGE NO. / BOREHOLE NO. (A) Cont'd.

PROFONDEUR DEPTH PIEDS FEET	MM	ELEVATION FEET	DESCRIPTION SURFACE DU SOL GROUND SURFACE	N.E W.L.	SYMB.	ECHANTILLONS SAMPLES TYPE/NO	REC %	RESISTANCE AU CISAILLEMENT ET A LA PENETRATION STRENGTH & PENETRATION RESISTANCE KPa 20 40 60 80 N	PROF. DEPTH Pi. Ft.	MM
65	20000	114.5	Bedrock: Grey fine-grained sandstone comprised of dolomite and limestone with some shaley beds and some sub-horizontal and sub-vertical joints. Fractured and weathered to 66.0'.			RC13	86	RQD=0%		
70	21000	21.46								
70.4		109.1								
	22000	33.25								
75	23000		End of borehole.							
	24000									
80	25000									
85	26000									
	27000									
90	28000									
95	29000									
	30000									

APPENDIX B

RECORD OF BOREHOLE SHEETS, PREVIOUS INVESTIGATIONS

PART 5

RECORD OF BOREHOLES 9, 10, 10A, 10B

by

E.M. Peto Associates Ltd.

Project 6113, 1961
(Water Street Reconstruction)

M. Peto Associates Ltd.

SOIL ENGINEERING SERVICE - TORONTO, ONTARIO

BOREHOLE LOG

Job Name: Sanitary Sewer - Cornwall | Job No.: 6113 | Borehole No.: 9

Client: Gore & Storrie Limited | Casing: BX | Boring Date: February 28, 1961

Elevation: Client's (176.08) | Compiled By: J.F.G. | Checked By: B.I.

SAMPLE CONDITION

- UNDISTURBED
- FAIR
- DISTURBED
- LOST

SAMPLE TYPE

- A.S. AUGER SAMPLE
- C.S. CASING SAMPLE
- S.S. 2" STANDARD SPLIT TUBE SAMPLE
- S.L. SPLIT BARREL WITH LINERS
- S.T. THIN-WALLED SHELBY TUBE SAMPLE
- W.S. WASH SAMPLE
- R.C. ROCK CORE

ABBREVIATIONS

- V.T. IN SITU VANE SHEAR TEST
- C. SOIL SHEAR STRENGTH LBS/SQ.FT.
- W.L. WATER LEVEL IN CASING
- W.T. GROUND WATER TABLE IN SOIL
- W.T.P.L. WETTER THAN PLASTIC LIMIT
- D.T.P.L. DRIER THAN PLASTIC LIMIT

SOIL DESCRIPTION	COLOUR	Density or Consistency	Depth / Elevation	Legend	Sample No. and Condition	Sample Type	No. of Blows per Ft.	Natural Moisture Content	WATER LEVELS & REMARKS
			176.1						
Org. clayey silt fill	Black	Hard	3'4"		1	S.S.	40	25.5	A.P.L.
Silty clay, organic pockets	Grey	Firm to stiff			2	S.S.	8	33.6	W.T.P.L.
					3	2"SL			
Silty clay, odd pebble	Grey	Firm			4	S.S.	5	40.0	W.T.P.L.
Silty sand fill organic matter, some clay	Grey	Firm	11'5"		5	2"SL		38.7	
					6	S.S.	7	19.8	V. Moist
Stone in liner									
Silty clay, sensitive	"	Firm to stiff	17'6"		7	2"SL			
					8	S.S.	8	21.9	W.T.P.L.
Silty sand till	"	Extremely dense			9	S.S.	100	6.9	Wet Started using wash water
Silty sand till, gravel layers	"	V. dense	25'0" 25'4"		10	S.S.	69	9.9	Wet
Silty sand till clay binder	"	Dense	30'0"		11	S.S.	39	11.2	V. Moist
As above	"	Compact	35'0"		12	S.S.	22	9.1	" "
									Stiffens at 39'0"
Silty sand till	"	V. dense	40'0"		13	S.S.	65	7.3	" "
Silty sand till	"	V. dense	45'0"		14	S.S.	75	7.3	" "
BOREHOLE TERMINATED AT 45'0"									

e. m. peto associates ltd.

SOIL ENGINEERING SERVICE - TORONTO, ONTARIO

BOREHOLE LOG

Job Name: Sanitary Sewer - Cornwall
Job No.: 6113
Borehole No.: 10
Client: Gore & Storrie Limited
Casing: BX
Boring Date: February 28th, 1961
Elevation: Client's (176.23)
Compiled By: J. F. G.
Checked By: B. I.

SAMPLE CONDITION

- UNDISTURBED
- FAIR
- DISTURBED
- LOST

SAMPLE TYPE

- A.S. AUGER SAMPLE
- C.S. CASING SAMPLE
- S.S. 2" STANDARD SPLIT TUBE SAMPLE
- S.L. SPLIT BARREL WITH LINERS
- S.T. THIN-WALLED SHELBY TUBE SAMPLE
- W.S. WASH SAMPLE
- R.C. ROCK CORE

ABBREVIATIONS

- V.T. IN SITU VANE SHEAR TEST
- C. SOIL SHEAR STRENGTH LBS/SQ.FT.
- W.L. WATER LEVEL IN CASING
- W.T. GROUND WATER TABLE IN SOIL
- W.T.P.L. WETTER THAN PLASTIC LIMIT
- D.T.P.L. DRIER THAN PLASTIC LIMIT

SOIL DESCRIPTION	COLOUR	Density or Consistency	Depth / Elevation	Legend	Sample No. and Condition	Sample Type	No. of Blows per Ft.	Water Content %	WATER LEVELS & REMARKS
			176.2						
Organic silty and sandy fill	Black	Hard	4'2"		1	S.S.	34	27.1	V. Wet
Silty clay fill, odd cinder	Grey	Soft			2	S.S.	3	40.8	V.T.P.L.
					3	2"SL			
Silty clay fill, odd cinder	"	V. Soft	10'0"		4	S.S.	3/30"	51.7	V.T.P.L.
					5	2"SL			
As above	"	Firm			6	S.S.	6	48.0	V.T.P.L.
As above	"	Stiff	15'8"		7	S.S.	12	42.0	V.T.P.L. stiffens
Silty clay fill, large stone, orange sand	"	V. stiff to hard	21'0"		8	S.S.	28	11.4	Water seam at 20'. Water V.T.P. rose to 14'7" in 2 minutes
Silty sand till and gravel layer	"	Compact	25'0"		9	S.S.	19		Wet
					10	2"SL			
Silty sand till, some clay	"	Compact	30'0"		11	S.S.	24	7.5	V. Moist
As above	"	V. dense	35'0"		12	S.S.	52	8.1	" "
As above	"	V. dense	41'0"		13	S.S.	74		" "
BOREHOLE TERMINATED AT 41'0"									No wash water used

WATER CONDITIONS

DATE	TIME	CASING DEPTH	HOLE DEPTH	WATER DEPTH	REMARKS
February 28, 1961	12:05	21'	21'	14'7"	Not balled
	12:07	21'	21'	10'3"	

e. m. peto associates ltd.

SOIL ENGINEERING SERVICE - TORONTO, ONTARIO

BOREHOLE LOG

Job Name: Sanitary Sewer - Cornwall | Job No.: 6113 | Borehole No.: 10A

Client: Gore & Storrie Limited | Casing: BX | Boring Date: March 1, 1961

Elevation: Client's (176.8) | Compiled By: J.F.G. | Checked By: B.L.

SAMPLE CONDITION

- UNDISTURBED
- FAIR
- DISTURBED
- LOST

SAMPLE TYPE

- A.S. AUGER SAMPLE
- C.S. CASING SAMPLE
- S.S. 2" STANDARD SPLIT TUBE SAMPLE
- S.L. SPLIT BARREL WITH LINERS
- S.T. THIN-WALLED SHELBY TUBE SAMPLE
- W.S. WASH SAMPLE
- R.C. ROCK CORE

ABBREVIATIONS

- V.T. IN SITU VANE SHEAR TEST
- C. SOIL SHEAR STRENGTH LBS/SQ.FT.
- W.L. WATER LEVEL IN CASING
- W.T. GROUND WATER TABLE IN SOIL
- W.T.P.L. WETTER THAN PLASTIC LIMIT
- D.T.P.L. DRIER THAN PLASTIC LIMIT

SOIL DESCRIPTION	COLOUR	Density or Consistency	Depth Elevation	Legend	Sample No. and Condition	Sample Type	No. of Blows per Ft	Natural Moisture Content	WATER LEVELS & REMARKS
			176.8						
Silty sandy fill	Black	Dense			1	S.S.	34	45.7	Saturated
Silty clay fill	Grey	Soft	5'8"		2	S.S.	3	48.2	W.T.P.L.
					3	2" SL		--	
Silty clay fill	Grey	Soft			4	S.S.	3	3.6	W.T.P.L.
			13'6"		5	2"SL			
Org. clayey silt fill (fine sand)	Grey	Compact	16'0"		6	S.S.	13	28.0	
			20'0"						
Silty sand	Grey	Extremely dense			7	S.S.	100/6"	9.3	V. Moist
Coarse sand and fine grave	"		22'0"		8	W.S.			Started using wash water
As above	"	Extremely dense			9	W.S.	200/1/2"	-	
Clayey sand till	"	Compact	30'6"		10	S.S.	21	10.7	A.P.L.
Silty sand till	"	Dense			11	S.S.	34	10.7	Moist
As above, some clay	Grey	V. dense	40'0"		12	S.S.	53	9.1	"
		BOREHOLE TERMINATED AT 40'0"							No water seams

e. m. peto associates ltd.

SOIL ENGINEERING SERVICE - TORONTO, ONTARIO

BOREHOLE LOG

Job Name: Sanitary Sewer - Cornwall | Job No.: 6113 | Borehole No.: 10B

Client: Gore & Storrie Limited | Casing: BX | Boring Date: March 8th, 1961

Elevation: Client's (179.4) | Compiled By: J. F. C. | Checked By: B. L.

SAMPLE CONDITION

- UNDISTURBED
- FAIR
- DISTURBED
- LOST

SAMPLE TYPE

- A.S. AUGER SAMPLE
- C.S. CASING SAMPLE
- S.S. 2" STANDARD SPLIT TUBE SAMPLE
- S.L. SPLIT BARREL WITH LINERS
- S.T. THIN-WALLED SHELBY TUBE SAMPLE
- W.S. WASH SAMPLE
- R.C. ROCK CORE

ABBREVIATIONS

- V.T. IN SITU VANE SHEAR TEST
- C. SOIL SHEAR STRENGTH LBS/SQ.FT.
- W.L. WATER LEVEL IN CASING
- W.T. GROUND WATER TABLE IN SOIL
- W.T.P.L. WETTER THAN PLASTIC LIMIT
- D.T.P.L. DRIER THAN PLASTIC LIMIT

SOIL DESCRIPTION	COLOUR	Density or Consistency	Depth / Elevation	Legend	Sample No. and Condition	Sample Type	No. of Blows per Ft.	Natural Moisture Content	WATER LEVELS & REMARKS
			179.4						
Organic sandy fill	Black	Compact to dense			1	S.S.	32	22.5	V. Moist
			5'4"						
Silty clay	Grey brown	Very stiff			2	S.S.	26	39.3	W.T.P.L.
Silty clay	" "	" "			3	S.S.	21	37.9	W.T.P.L.
As above	" "	Very stiff			4	S.S.	18	47.3	"
					5	2"SL			
As above	" "	Stiff			6	S.S.	12	45.5	"
			17'8"						Water seams at 18'0" - water rose to 17'10"
					7	2"ST			
Silty sand till	" "	Very dense			8	S.S.	73		Moist
As above	" "	Extremely dense	25'6"		9	S.S.	120/6"	5.7	"
	BOREHOLE TERMINATED AT 25'6"								No water in hole upon completion of drilling.

APPENDIX C

RECORD OF BOREHOLES FROM PRESENT INVESTIGATION

This appendix presents the borehole logs from the initial investigation of the former manufactured gas plant site in Cornwall.

The records of boreholes are presented in two parts as follows:

Part 1	Borehole Descriptions, Phase I
Part 2	Record of Borehole Sheets, Phase II

APPENDIX C

RECORD OF BOREHOLES FROM PRESENT INVESTIGATION

PART 1

BOREHOLE DESCRIPTIONS, PHASE I

RECORD OF BOREHOLES PHASE I

Borehole Number	Depth (metres)	Soil Description
I-1	0.00 - 0.48	**FILL** - asphalt over sand and gravel mixed with clay, frost to approximately 0.36 m.
	0.48 - 0.61	**FILL** - clay, stiff, brown moist, black cinders in layer about 1 cm thick at 0.61 m.
	0.61 - 0.76	**CLAY** - brown, stiff, appears to be native End of Hole (reading on TIP 0 ppm)
I-2	0.00 - 0.45	**FILL** - asphalt over sand and gravel mixed with clay, frost to approximately 0.36 m.
	0.45 - 0.58	**FILL** - clay, stiff, brown, moist, black cinders in layer about 1 cm thick at 0.58 m
	0.58 - 0.61	**CLAY** - brown, stiff, appears to be native End of Hole (reading on TIP 0 ppm)
I-3	0.00 - 0.47	**FILL** - asphalt over sand and gravel, some clay frost to approximately 0.37 m.
	0.47 - 0.61	**FILL** - clay, stiff, brown black cinders in layer about 1 cm thick of 0.61 cm
	0.61 - 0.78	**CLAY** - brown, stiff, appears to be native End of Hole (reading on TIP 0 ppm)
I-4	0.00 - 0.47	**FILL** - asphalt over sand and gravel, some clay frost to approximately 0.32 m.
	0.47 - 0.61	**FILL** - black cinders and sand, stained with black oil material (reading on TIP 51 ppm) End of Hole (reading on TIP 58 ppm)
I-5	0.00 - 0.50	**FILL** - clay, some gravel End of Hole (reading on TIP 0 ppm)
I-6	0.00 - 0.40	**FILL** - asphalt over sand and gravel, some clay, frost to approximately 0.37 m End of Hole at 0.4 m due to equipment breakdown (reading on TIP 0 ppm)

Borehole Number	Depth (metres)	Soil Description
I-7	0.00 - 0.41	**FILL** - asphalt over sand and gravel, frost to 0.37 m
	0.41 - 0.61	**FILL** - sand, medium to fine grained
	0.61 - 1.07	**FILL** - clay, soft, brown some dark stains, some frost lenses (reading on TIP 8 ppm)
	1.07 - 1.68	**FILL** - sand, gravel, cinders, some brick fragments (reading on TIP 0 ppm)
	1.68 - 1.98	**FILL** - sand and gravel, stained black, free oily black liquid in fill definite odour (reading on TIP 16 ppm) End of Hole

APPENDIX C

RECORD OF BOREHOLE SHEETS FROM PRESENT INVESTIGATION

PART 2

RECORD OF BOREHOLE SHEETS, PHASE II

RECORD OF BOREHOLE II-1

SHEET 1 of 1

LOCATION See Figure 2

BORING DATE May.4,1988

DATUM GEODETIC

SAMPLER HAMMER, 63.5kg, DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg, DROP, 760mm

PROJECT 881-2706

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (M)	SAMPLES: NUMBER	TYPE	BLOWS/0.3M	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, CM/SEC	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger 80mm Inside Diam (Hollow Stem)	Ground Surface		53.88				0.00-0.03 ASPHALT			Bentonite Seal
		FILL - medium grained sand, silt, gravel		0.03 53.40							
1				0.48	1	CS	-				Backfill
2		SILTY CLAY (Weathered Crust) - brown very stiff to stiff			2	CS	-				38mm PVC Riser Pipe
3					3	CS	-				
4				49.88 4.00							Bentonite Seal
5		SILTY CLAY - grey, stiff			4	CS	-				38mm PVC #10 Slot Screen
6		GLACIAL TILL - grey silty sand some gravel		47.92 5.94	5	CS	-				
		End of Hole		47.61 6.25							
7											W.L in Screen at Elev. 51.06 May.25,1988
8											
9											
10											

SHEAR STRENGTH Cu, kPa — nat.V.- + Q.- ● rem.V.- ⊕ U.- ○

WATER CONTENT, PERCENT — Wp, W, Wl — 20 40 60 80

0 15 10 5 PERCENT AXIAL STRAIN AT FAILURE

DEPTH SCALE

1 : 50

Golder Associates

LOGGED S.L

CHECKED

RECORD OF BOREHOLE II-2

SHEET 1 of 1

LOCATION See Figure 2

BORING DATE May.5,1988

DATUM GEODETIC

SAMPLER HAMMER, 63.5kg, DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg, DROP, 760mm

PROJECT 881-2705

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (M)	SAMPLES: NUMBER	TYPE	BLOWS/0.3M	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / SHEAR STRENGTH Cu, kPa (nat.V.- + Q.- ● rem.V.- ⊕ U.- ○)	HYDRAULIC CONDUCTIVITY, k, CM/SEC / WATER CONTENT, PERCENT (Wp, W, Wl; 20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger 80mm Inside Diam (Hollow Stem)	Ground Surface		53.96				0.00-0.03 ASPHALT			Bentonite Seal
				0.03							
1		FILL - brown silty sand, gravel, cinders, occasional brick			1	CS	-				
				52.66							Backfill
				1.30							38mm PVC Riser Pipe
2					2	CS	-				
		SILTY CLAY (Weathered Crust) - brown very stiff to stiff									
3					3	CS	-				
				49.96							
4				4.00							Bentonite Seal
		SILTY CLAY - grey, stiff									
5					4	CS	-				
				48.17							
6		GLACIAL TILL - grey silty sand with gravel		5.79	5	CS	-				38mm PVC #10 Slot Screen
				47.56							
		End of Hole		6.40							
7											W.L in Screen at Elev. 51.95 May. 25, 1988
8											
9											
10											

0 / 16 / 10 PERCENT AXIAL STRAIN AT FAILURE

DEPTH SCALE

1 : 50

Golder Associates

LOGGED S.L

CHECKED

RECORD OF BOREHOLE II-3

SHEET 1 of 1

LOCATION See Figure 2

BORING DATE May.4,1988

DATUM GEODETIC

SAMPLER HAMMER, 63.5kg, DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg, DROP, 760mm

PROJECT 881-2705

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (M)	SAMPLES: NUMBER	TYPE	BLOWS/0.3M	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / SHEAR STRENGTH Cu, kPa (nat.V.- + Q.- ● rem.V.- ⊕ U.- O)	HYDRAULIC CONDUCTIVITY, k, CM/SEC / WATER CONTENT, PERCENT (Wp, W, Wl; 20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface		53.68				0.00-0.03 ASPHALT			Bentonite Seal
		FILL - brown sandy with gravel		0.03 / 53.22							
1	Power Auger 80mm Inside Diam (Hollow Stem)			0.46	1	CS	-				Backfill
		FILL - brown silty clay with traces sand, dark brown organic layering occasional fine gravel			2	CS	-				38mm PVC Riser Pipe
2		* - black organic material with free oil product from 3.05 to 3.81m									
3		* later identified as coal tar wastes			3	CS	-				Bentonite Seal
				49.87							
4		SILTY CLAY - brown weathered becoming grey, very stiff to stiff		3.81							
					4	CS	-				38mm PVC #10 Slot Screen
5				48.19							
		GLACIAL TILL		5.49							
		End of Hole		5.64							W.L in Screen at Elev. 50.29 May.25,1988
6											
7											
8											
9											
10											

0 15 10 PERCENT AXIAL STRAIN AT FAILURE

DEPTH SCALE

1 : 50

Golder Associates

LOGGED S.L

CHECKED

RECORD OF BOREHOLE II-4

SHEET 1 of 1

LOCATION See Figure 2

BORING DATE May.4,1988

DATUM GEODETIC

SAMPLER HAMMER, 63.5kg, DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg, DROP, 760mm

PROJECT 881-2705

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (M)	SAMPLES: NUMBER	TYPE	BLOWS/0.3M	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / SHEAR STRENGTH Cu, kPa (nat.V.- + Q.- ●, rem.V.- ⊕ U.- O)	HYDRAULIC CONDUCTIVITY, k, CM/SEC / WATER CONTENT, PERCENT (Wp, W, Wl; 20, 40, 60, 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger 80mm Inside Diam (Hollow Stem)	Ground Surface		53.68				0.00-0.03 ASPHALT			
		FILL - brown, sand with gravel		0.03 / 53.33							
		FILL - dark brown to black, silty sand, cinders		0.35 / 53.03	1	CS	-				
1		FILL - brown, silty sand		0.65 / 52.46							
				1.22	2	CS	-				
2		SILTY CLAY - brown, very stiff and weathered to 4.3m with traces of black staining from 1.22 to 2.59m, becoming grey and stiff below 4.30m									
3					3	CS	-				
4											
5					4	CS	-				
				48.50							
		GLACIAL TILL		5.18 / 48.04							
6		End of Hole		5.64							
7											
8											
9											
10											

0 / 15 / 10 PERCENT AXIAL STRAIN AT FAILURE

DEPTH SCALE

1 : 50

Golder Associates

LOGGED S.L

CHECKED

RECORD OF BOREHOLE II-5

SHEET 1 of 1

LOCATION See Figure 2

BORING DATE May.5,1988

DATUM GEODETIC

SAMPLER HAMMER, 63.5kg, DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg, DROP, 760mm

PROJECT 881-2706

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (M)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3M	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / SHEAR STRENGTH Cu, kPa (nat.V.- + Q.- ● rem.V.- ⊕ U.- O)	HYDRAULIC CONDUCTIVITY, k, CM/SEC / WATER CONTENT, PERCENT Wp W Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger 80mm Inside Diam (Hollow Stem)	Ground Surface		53.76				0.00-0.03 ASPHALT			
				0.03							
		FILL - brown, sand and gravel, trace silt			1	CS	-				
1				52.69							
				1.07							
		FILL - brown, silty clay, sand, brick, gravel, glass, cinder			2	CS	-				
2											
3				50.71							
		FILL - concrete, sand, clay, free oil observed.		3.05							
				50.41							
		FILL / ORGANIC MATERIAL - black organic material * (peat-like), free oil present		3.35	3	CS	-				
				50.10							
4		* later identified as coal tar wastes		3.66							
		SILTY CLAY - brown weathered crust			4	CS	-				
5											
				48.12							
		End of Hole		5.64							
6											
7											
8											
9											
10											

0 / 16 ◆ 6 / 10 PERCENT AXIAL STRAIN AT FAILURE

DEPTH SCALE

1 : 50

Golder Associates

LOGGED S.L

CHECKED

APPENDIX D

RESULTS OF CHEMICAL ANALYSES

This appendix presents the results of the chemical analyses carried out by ZENON Environmental Inc. on soil and water samples. Included are tables presenting the results as well as documentation regarding analytical methods.

The results of the analyses are presented in two parts as follows:

Part 1 Results of Analyses and supporting documentation, Phase I

Part 2 Results of Analyses and supporting documentation, Phase II

APPENDIX D

RESULTS OF CHEMICAL ANALYSES

PART 1

RESULTS OF ANALYSES AND SUPPORTING DOCUMENTATION
PHASE I

Zenon Environmental Inc.
845 Harrington Court, Burlington, Ontario L7N 3P3 Tel.: (416) 639-6320 Telex: 061-8734 Fax: 639-1812

File No: AN888346

April 6th, 1988
Mr. Bruce Wilson
GOLDER ASSOCIATES
1796 Courtwood Cresent,
Ottawa, Ontario
K2C 2B5

Dear Bruce:

The sample of soil submitted to ZENON Environmental Inc. was extracted and the extract was analyzed by GC/MS to characterize the organics present.

Since many of the compounds found are not available as standards, the concentrations of the organics are estimated and are based on the response of an internal standard added to the sample immediately prior to the GC/MS analysis. This compound is also a PAH and its response will be similar to the other compounds detected.

The attached table provides the identification of the organics observed together with their concentrations. All the compounds seen were polyaromatic hydrocarbons (PAH). The sample was difficult to evaporate to a low volume; indicating the presence of high boiling compounds which would not be observed by GC/MS. The presence of the range of PAH seen and their relative concentrations is similar to that expected in coal tar samples and this is a likely source.

If you have any questions or concerns, please do not hesitate to contact me.

Yours truly,

MG Foster

Glenys Foster
Manager Analytical Services

GF/sk
Encls. (2)

GC/MS CHARACTERIZATION OF SOIL SAMPLE	CONCENTRATION ug/g
Acenaphthene	2
Fluorene	3
Phenanthrene	22
Anthracene	4
Carbazole	2
Methyl Phenanthrene	5
Cyclopentaphenanthrene	8
2-Phenylnaphthalene	4
Sulphur	28
Fluoranthene	22
Pyrene	18
Methyl 2-phenyl naphthalene	3
Methyl fluoranthene/pyrene Total (4 isomers)	14
Terphenyl Total (2 isomers)	4
Benzo(a)anthracene	9
Chrysene	9
Bis(2-ethylhexyl)phthalate	4
Benzo(b+k)fluoranthene	15
Benzo(j)fluoranthene	4
Benzo(a)pyrene	9
Benzo(e)pyrene	9
Perylene	4
Indenopyrene	5
Benzo(ghi)perylene	3
Dibenz(a,h)anthracene	2

881-2705

Zenon Environmental Inc.
845 Harrington Court, Burlington, Ontario L7N 3P3 Tel.: (416) 639-6320 Telex: 061-8734 Fax: 639-1812

File No. AN888346

July 22, 1988

Bruce Wilson
Golder Associates
1796 Courtwood Cres.
Ottawa, Ontario
K2C 2B5

Dear Bruce:

In response to our recent telephone conversation regarding my report to you of April 6, 1988, I would like to clarify our use of internal standards in environmental analysis.

For the analysis of PAH related materials, Zenon used deuterated phenanthrene (D_{10}-P) as an internal standard. An identical amount of D_{10}-P is added to each sample immediately prior to the injection of the sample into the GC/MS system. The mass spectrometer is able to distinguish between native phenanthrene and deuterated phenanthrene because their masses are different.

Many of the compounds found were not available to us as pure standards and consequently their mass spectrometric responses have not been determined. In order to provide accurate data, standards of each component must be run in conjunction with the samples. In an analytical situation where the prime requirement is characterization of the organics present, prior to quantification of target organics, it is not possible to anticipate the standards which will be required for the analysis. The approach then taken is to compare the mass spectrometric response of the compound found to the response of the deuterated phenanthrene added to the sample immediately prior to injection. This approach gives a good estimate of the concentration of organics present.

I hope this helps to clarify the value of internal standards. If you have any further questions or concerns, please call.

Sincerely,

R.A.M Foster

for M. Glenys Foster, Ph.D.,
Manager, Analytical Services

MGF/mh
Attch.

APPENDIX D

RESULTS OF CHEMICAL ANLAYSES

PART 2

RESULTS OF ANALYSES AND SUPPORTING DOCUMENTATION
PHASE II

Zenon Environmental Inc.
845 Harrington Court, Burlington, Ontario L7N 3P3 Tel.: (416) 639-6320 Telex: 061-8734 Fax: 639-1812

File No: AN888346
Work No: A 1487

July 7th, 1988

Bruce Wilson
GOLDER ASSOCIATES
1796 Courtwood Cres.,
Ottawa, Ontario
K2C 2B5

Dear Bruce:

The results for the samples submitted to us are given in the following tables.

The samples will be stored at ZENON for three weeks from the date above, at which time they will be discarded. Arrangements can be made for longer storage times by calling me.

If you have any questions or concerns, please do not hesitate to contact me.

Yours truly,

Michael N. Smith
Senior Inorganic Chemist

MNS;sk
Encl.

	Parameter (mg/l)	882625 BH II-1 20.5'	882626 BH II-2 8.5'	882629 BH II-2 21'	882630 BH II-3 3.5'
leachate	Fluoride	< 0.1	< 0.1	< 0.1	< 0.1
	Chloride	< 0.2	< 0.2	< 0.2	6.0
	Nitrite (as N)	< 0.2	< 0.2	< 0.2	< 0.2
	Bromide	< 0.8	< 0.8	< 0.8	< 0.8
	Nitrate (as N)	< 0.2	< 0.2	< 0.2	1.0
	Phosphate (as P)	< 0.8	< 0.8	< 0.8	< 0.8
	Sulfate	< 1.0	3.0	5.0	5.0
	Arsenic	< 0.01	< 0.01	< 0.01	< 0.01
	Calcium	1500	57	1100	210
	Magnesium	27	7.6	38	5.0
	Sodium	1.8	8.1	3.1	9.4
	Potassium	3.2	2.2	5.0	2.9
	Aluminum	0.36	0.19	0.86	0.2
	Barium	1.3	0.065	1.6	0.16
	Beryllium	< 0.001	< 0.001	0.002	< 0.001
	Boron	0.14	0.16	0.17	0.15
	Cadmium	< 0.003	< 0.003	< 0.003	< 0.003
	Chromium	0.010	< 0.004	0.026	0.006
	Cobalt	0.01	< 0.01	< 0.01	< 0.01
	Copper	0.015	< 0.006	0.045	< 0.006
	Iron	0.98	0.095	1.5	0.11
	Lead	< 0.05	< 0.05	< 0.05	< 0.05
	Manganese	5.2	0.92	3.8	0.089
	Molybdenum	< 0.02	< 0.02	< 0.02	< 0.02
	Nickel	0.055	0.017	0.011	0.011
	Phosphorous	< 0.1	< 0.1	0.22	< 0.1
	Silicon	1.5	4.5	4.1	2.2
	Silver	< 0.01	< 0.01	< 0.01	< 0.01
	Strontium	3.4	0.23	2.6	0.59
	Sulphur	14	1.1	13	3.5
	Thallium	0.09	< 0.05	< 0.05	< 0.05
	Titanium	0.02	< 0.01	0.051	< 0.01
	Vanadium	< 0.02	< 0.02	< 0.02	< 0.02
	Zinc	0.043	0.019	0.045	0.04
	Zirconium	< 0.01	< 0.01	< 0.01	< 0.01

Parameter (mg/l)	882354 MW#1	882355 MW#2	882356 MW#3	882357 Bailor Blank
pH (20 °C)	8.09	8.19	7.99	6.72
COD	< 10	< 10	760	< 10
TOC	5.5	5.0	40	< 1.0
Total Phenolics	< 0.1	< 0.1	0.77	< 0.1
Total Cyanide	< 0.01	< 0.01	< 0.01	< 0.01
Ammonia (as N)	< 0.01	< 0.01	0.014	< 0.01
TKN (as N)	< 0.3	< 0.3	< 0.3	< 0.3
Sulfide	< 0.001	0.032	< 0.001	< 0.001
Fluoride	< 0.1	< 0.1	< 0.1	< 0.1
Chloride	240	89	270	< 0.2
Nitrite (as N)	< 0.2	< 0.2	< 0.2	< 0.2
Bromide	< 0.8	< 0.8	< 0.8	< 0.8
Nitrate (as N)	< 0.2	< 0.2	< 0.2	< 0.2
Phosphate (as P)	< 0.8	< 0.8	< 0.8	< 0.8
Sulfate	70	100	18	< 1.0
Alkalinity (as CaCO3)	360	200	460	3.6
Calcium	170	68	180	0.14
Magnesium	52	30	48	0.015
Sodium	33	52	90	1.3
Potassium	3.1	11	17	< 0.4
Aluminum	0.13	0.10	0.21	0.37
Barium	0.072	0.16	0.38	0.006
Beryllium	< 0.001	< 0.001	< 0.001	< 0.001
Boron	0.25	0.28	0.60	0.74
Cadmium	< 0.005	< 0.005	< 0.005	< 0.005
Chromium	< 0.01	< 0.01	< 0.01	< 0.01
Cobalt	0.02	< 0.01	< 0.01	< 0.01
Copper	< 0.01	< 0.01	< 0.01	< 0.01
Iron	0.037	0.050	0.039	< 0.01
Lead	< 0.04	< 0.04	< 0.04	< 0.04
Manganese	0.91	0.90	0.98	< 0.005
Molybdenum	< 0.01	< 0.01	< 0.01	< 0.01
Nickel	0.018	< 0.01	< 0.01	< 0.01
Phosphorous	0.51	0.46	0.80	< 0.1
Silicon	9.6	5.5	9.2	< 0.05
Silver	< 0.01	< 0.01	< 0.01	< 0.01
Strontium	0.67	12	16	0.002
Sulfur	25	30	9.3	0.19
Thallium	< 0.05	< 0.05	< 0.05	< 0.05
Titanium	< 0.01	< 0.01	< 0.01	< 0.01
Vanadium	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	0.048	< 0.01	0.073	< 0.01
Zirconium	< 0.01	< 0.01	< 0.01	< 0.01

ANALYSIS OF CORNWALL SITE WATERS AND SOILS FOR BTEX AND PAH

Report for:

GOLDER ASSOCIATES

Prepared by:

ZENON ENVIRONMENTAL INC.

845 Harrington Court,

Burlington, Ontario

L7N 3P3

July 15, 1988

File No: AN888346

Zenon Environmental Inc.
845 Harrington Court, Burlington, Ontario L7N 3P3 Tel.: (416) 639-6320 Telex: 061-8734 Fax: 639-1812

File No: AN888346

July 20th, 1988

Bruce Wilson
GOLDER ASSOCIATES
1796 Courtwood Cres.,
Ottawa, Ontario
K2C 2B5

Dear Bruce:

Please find enclosed the report entitled "Analysis of Cornwall Site Waters and Soils for BTEX and PAH". All data is complete and finalized.

Should any questions arise do not hesitate to contact me.

Yours truly,

R. A. McLeod

Ron A. McLeod, Ph.D.
Senior Chemist

RAM;sk
Encls. (3)

1.0 INTRODUCTION

1.0 **INTRODUCTION**

Four waters and nine soils were submitted to ZENON Environmental Inc. by Golder Associates from the Cornwall site for analysis of BTEX (the waters only), and PAH. The following report describes the analytical methodologies (Section 2), presents the anlytical results (Section 3) and describes the QA/QC protocols employed (Section 4).

2.0 METHODOLOGY

2.0 METHODOLOGY

2.1.1. Polyaromatic Hydrocarbons - Soils

Approximately 10 g wet weight of each soil was accurately weighed. Sodium sulphate was added to the sample and mixed until granular, then placed into a 125 mL bottle. The sample was spiked with two deuterated surrogate standards, anthracene - $^2H_{10}$ and benzo(a)pyrene - $^2H_{12}$ to determine recovery of typical compounds of interest. The sample was extracted twice into a 50/50 acetone/hexane solution by shaking on a wrist shaker for 30 minutes. The phases were separated and the solvent was passed through a 4 cm anhydrous Na_2SO_4 column in an Allihn filter. Additional acetone/hexane was used to wash the walls of the Allihn filter and suction was applied to recover all traces of the extract. The extract was then rotary evaporated to approximately 5 mL with solvent exchange into isooctane.

One fifth of the extract was subjected to alumina clean-up by eluting the extract through a .5 cm X 10 cm column packed with freshly activated basic alumina with hexane (10 mL) then with 50/50 hexane/dichloromethane (15 mL). The second fraction containing the PAHs was transferred to a calibrated centrifuge tube, solvent exchanged into isooctane and concentrated to 1.0 mL volume.

Immediately prior to instrumental analysis the sample is spiked with a deuterated internal standard, phenanthrene - $^2H_{10}$, to compensate for variation in injection volume, instrument conditions etc.

2.1.2 Polyaromatic Hydrocarbons - Waters

The volume of the sample was measured in a 1L graduated cylinder and poured into a 2L separatory funnel. 10 mL of methylene chloride was used to rinse the cylinder and this was transferred into the funnel, together with an additional 100 mL of methylene chloride. The sample was spiked with deuterated surrogate standards anthracene $-^2H_{10}$, and benzo(a)pyrene - $^2H_{12}$ to monitor recovery in the procedure.

The sample was shaken vigorously for 1 minute and when the phases had separated the methylene chloride extract was drained through a 1.5 inch anhydrous Na_2SO_4 column in an Allihn filter. The aqueous portion was re-extracted twice as above with 75 mL of methylene chloride. 20 mL of methylene chloride was used to wash the walls of the Allihn filter and suction was applied to recover all traces of the extract. The extract was then rotary evaporated to approximately 2 mL and quantitatively transferred to a calibrated centrifuge tube to a final volume of 1.0 mL for GC/MS analysis. Immeditely prior to instrumental analysis, the sample is spiked with a deuterated internal standard phenanthrene - $^2H_{10}$ to compensate for variations in injection volume, instrument conditions, etc.

2.1.3 **PAH Analysis**

PAH extracts were analysed on a Finnigan 4500 GC/MS. Instrumental conditions are listed below:

GC/MS Analysis

Gas Chromatography

Injection Mode	On Column
Column	30 m DB5 x 0.25 mm ID
Column Flow	He @ 20 cm/sec.

Oven Temp. profile

80°C - 2 min.;

80°C -- 210°C @ 10°/min; 210°C --- 290° @ 16°C/min. hold 10 min.

GC/MS Interface - Direct Couple

Transfer Area - 250°C

Mass Spectrometry

Ionization Mode	Electron Impact
Electron Energy	70 eV
Filament Emmission	0.5 A
Electron Multiplier	1400 V
Scan	Stepped ion MID

Quantification

The compounds of interest and the quantification ions used are presented below with the secondary ion given in brackets.

Compound	Quantification Ion
Naphthalene	128
Acenaphthylene	152
Acenaphthene	154 (152)
Fluorene	166 (165)
Phenanthrene	178
Anthracene	178
Fluoranthene	202 (101)
Pyrene	202 (101)
Chrysene	228 (114)
Benz(a)anthracene	228 (114)
Benzo(b)fluoranthene	252 (126)
Benzo(k)fluoranthene	252 (126)
Benzo(a)pyrene	252 (126)
Indeno(1,2,3-c,d)pyrene	276 (138)
Dibenzo(a,h)anthracene	278 (139)
Benzo(g,h,i)perylene	276 (138)

Quantification was carried out by comparing mass spectrometric responses of selected ions to those of external standards. Calculations were based on a final volume of 1 mL and no correction has been made for recovery of deuterated surrogate spikes.

The criteria used for the identification of the organics required:

a) the presence of appropriate secondary ions in the mass spectrum

b) signal to noise of a least 3 to 1

c) retention time within 2% of reference standard

2.1.4 Calculations

The concentration of contaminants in each sample were calculated according to the following formula:

Concentration of component in sample (ug/g or ug/L).

$= A_C/A_S \times I_S/I_C \times F/W \times C$

where

A_C = Area counts of compound in sample run

A_S = Area counts of compound in standard run

I_S = Area counts of internal standard in standard run

I_C = Area counts of internal standard in sample run

F = Final volume of extract (mL)

W = Dry weight of sample in grams or sample volume in litres

C = Concentration of component in standard (ug/mL)

The use of an internal standard in the calculation of contaminant concentration compensates for variations in injection volume, in between run instrument response and in differences in extract final volume.

2.2 BTEX Analysis

Three mL of the water sample was removed from a previously full 250 mL syringe-capped sample bottle and replaced with 2 mL of pentane. The bottle was shaken for 30 minutes and 2 uL of the resulting pentane extract was analysed directly by GC/FID against external standards.

2.2.1 Gas Chromatography

Injection Mode:	Splitless
Column:	30 m DB-1701N 0.2 mm ID
Column Head Pressure:	10 psi Hydrogen
Injector Temperature:	150°C
Oven Temperature Profile:	35°C - 1 min.
	35°C to 100°C @ 4°/min.
	100°C - hold 10 min.

3.0 ANALYTICAL RESULTS

3.0 **ANALYTICAL RESULTS**

Table 3.1 presents the PAH levels determined in the four waters. The sample extract for MW #1, was analysed twice by GC/MS. The table includes the data from both analytical runs. The lack of surrogate recoveries in the Bailor and Method blanks is unexplained but the problem is currently under investigation. No additional Bailor blank sample was available to repeat the analysis. Two samples MW #2 and #3 had PAH at levels which required analysis of diluted extracts. At the analysed dilutions recoveries could not be determined.

Table 3.2 presents the BTEX data on the water samples. Predictably, the sample with high PAH levels (MW #3) also showed high BTEX levels.

Table 3.3 presents the soil PAH data. PAH were found in all samples. Atypical were the levels of perylene in two samples (BH II-2 17' and 31'). In environmental samples, it is not usual for perylene to be at a level higher than benzo(a&e)pyrenes and benzo(b&k)fluoranthenes. However, overall, these two samples had PAH's at very low levels.

Surrogate compounds are added to each sample prior to extraction to monitor the efficiency of the extraction process. Low recoveries often indicate sample matrix effect rather than problems with the extraction procedure. Surrogates are chosen to be similar in structure to the parameters being analysed. Anthracene - d_{10} and benzo(a)pyrene - d_{12} are ideal surrogates for PAH analysis since they behave physically and chemically identical to the native (non-deuterated) PAH's. The substitution of deuterium for hydrogen

provides the surrogates with a molecular weight higher than the native PAH's and ensure that their mass spectral response does not interfer with that of the native materials.

Table 3.1: Polyaromatic Hydrocabons (µg/L)

Golder Proj # 881-2705

Sample Description:		MW #1	MW #1 Re-Analysis	MW #2	MW #3	Bailor Blank	Method Blank
Zenon ID #:		882354	882354	882355	882356	882357	
Polyaromatic Hydrocarbons	MDL						
Naphthalene	0.01	0.039	0.051	0.39	9400	0.060	0.026
Acenaphthylene	0.01	0.026	0.023	0.14	1200	<	<
Acenaphthene	0.01	0.065	0.049	0.23	2100	<	<
Fluorene	0.01	0.040	0.039	0.16	2200	<	<
Phenanthrene	0.01	0.077	0.073	1.1	5400	<	<
Anthracene	0.01	< 0.02	< 0.02	0.26	1500	<	<
Fluoranthene	0.01	0.082	0.072	1.1	2600	<	<
Pyrene	0.01	0.090	0.083	1.1	3200	<	<
Benz(a)anthracene	0.01	0.034	0.028	0.35	710	<	<
Chrysene	0.01	0.038	0.031	0.46	770	<	<
Benzo(b+k)fluoranthene	0.01	0.066	0.055	0.78	880	<	<
Benzo(j)fluoranthene	0.01	0.012	0.015	0.12	160	<	<
Benzo(e)pyrene	0.01	0.013	0.012	0.24	210	<	<
Benzo(a)pyrene	0.01	0.018	0.017	0.37	450	<	<
Perylene	0.01	<	<	0.17	80	<	<
Indeno(1,2,3-cd)pyrene	0.01	0.038	0.035	0.81	560	<	<
Dibenz(ah)anthracene	0.01	<	<	0.09	95	<	<
Benzo(ghi)perylene	0.01	0.034	0.038	1.2	580	<	<
Surrogate Recovery (%)							
d-10 Anthracene		41	47	DIL	DIL	NR	NR
d-12 Benzo(a)pyrene		46	42	DIL	DIL	NR	NR

< (#) = Not detected at MDL (at #).
MDL = Minimum detection limits
NR = Not recovered
DIL = Analysis of the diluted extract forced the MS sensitivity below that required for surrogate determination.

Table 3.2: Benzene, Toluene, Ethylbenzene & Xylenes (µg/L) Golder Proj # 881-2705

Sample Description:		MW #1	MW #2	MW #3	Bailor Blank	Method
Zenon ID #:		882354	882355	882356	882357	Blank
PARAMETER						
	MDL					
Benzene	50	<	<	2400	<	<
Toluene	50	<	<	960	<	<
Ethylbenzene	50	<	<	500	<	<
Xylenes	50	<	<	2100	<	<

< = Not Detected at MDL
MDL = Minimum detection limits

Table 3.3: Polyaromatic Hydrocabons (µg/g)

Golder Proj # 881-2705

Sample Description:		BH II-1 10'	BH II-2 13.5'	BH II-2 17'	BH II-2 21'	BH II-3 11'	BH II-3 13.5'
Zenon ID #:		882624	882627	882628	882629	882631	882632
Polyaromatic Hydrocarbons	MDL						
Naphthalene	0.03	<	<	<	<	0.11	0.10
Acenaphthylene	0.01	<	<	<	<	11	1.1
Acenaphthene	0.01	<	0.022	<	<	2.1	0.39
Fluorene	0.01	<	0.016	<	<	18	34
Phenanthrene	0.01	0.013	0.068	<	0.025	50	15
Anthracene	0.01	<	0.014	<	<	12	3.8
Fluoranthene	0.01	0.023	0.045	<	0.040	24	9.7
Pyrene	0.01	0.068	0.046	<	0.094	29	12
Benz(a)anthracene	0.01	0.022	<	<	0.020	6.0	2.1
Chrysene	0.01	0.045	0.016	<	0.084	6.7	2.7
Benzo(b+k)fluoranthene	0.01	<	0.023	<	<	8.0	2.9
Benzo(j)fluoranthene	0.01	<	<	<	<	1.2	0.48
Benzo(e)pyrene	0.01	<	<	<	<	1.8	0.69
Benzo(a)pyrene	0.01	<	<	<	<	3.7	1.5
Perylene	0.01	<	<	0.017	0.066	0.70	0.26
Indeno(1,2,3-cd)pyrene	0.01	<	0.010	<	<	3.0	1.1
Dibenz(ah)anthracene	0.01	<	<	<	<	0.73	0.28
Benzo(ghi)perylene	0.01	<	0.013	<	<	3.9	1.6
Surrogate Recovery (%)							
d-10 Anthracene		100	94	75	108	91	123
d-12 Benzo(a)pyrene		113	83	40	107	86	91

< (#) = Not detected at MDL (at #).
MDL = Minimum detection limits
DIL = Analysis of the diluted extract forced the MS sensitivity below that required for surrogate determination.

Table 3.3: Polyaromatic Hydrocabons (µg/g) Golder Proj # 881-2705

Sample Description:		BH II-4 13.5'	BH II-4 18.5'	BH II-5 11'	BH II-5 18.5'	
Zenon ID #:		882633	882634	882635	882636	Method Blank
Polyaromatic Hydrocarbons	MDL					
Naphthalene	0.02	0.036	<	88	0.042	<
Acenaphthylene	0.01	<	<	1.0	0.85	<
Acenaphthene	0.01	0.031	0.014	59	0.74	<
Fluorene	0.01	0.089	0.012	54	3.7	<
Phenanthrene	0.01	0.071	0.024	150	10	<
Anthracene	0.01	0.71	<	76	2.4	<
Fluoranthene	0.01	0.13	0.014	93	4.1	<
Pyrene	0.01	0.037	0.043	77	4.8	<
Benz(a)anthracene	0.01	0.35	<	42	0.67	<
Chrysene	0.01	0.39	<	53	0.81	<
Benzo(b+k)fluoranthene	0.01	0.37	<	61	1.1	<
Benzo(j)fluoranthene	0.01	0.051	<	6.6	0.19	<
Benzo(e)pyrene	0.01	0.059	<	13	0.29	<
Benzo(a)pyrene	0.01	0.18	<	22	0.59	<
Perylene	0.01	0.018	<	4.5	0.16	<
Indeno(1,2,3-cd)pyrene	0.01	0.14	<	27	0.49	<
Dibenz(ah)anthracene	0.01	0.036	<	4.9	0.11	<
Benzo(ghi)perylene	0.01	0.14	<	27	0.71	<
Surrogate Recovery (%)						
d-10 Anthracene		76	76	DIL	111	66/96
d-12 Benzo(a)pyrene		79	53	DIL	90	23/84

< (#) = Not detected at MDL (at #).
MDL = Minimum detection limits
DIL = Analysis of the diluted extract forced the MS sensitivity below that required for surrogate determination.

4.0 QUALITY ASSURANCE

4.0 **QUALITY ASSURANCE**

Quality control measures were taken in this work for the sample preparation, gas chromatographic and mass spectrometric areas and are as follows:

i) Samples were received and immediately refrigerated to preserve sample integrity.

ii) Mass assignments for ions generated by GC/MS were determined from a calibration of an FC43 perfluorohydrocarbon mixture.

iii) Surrogate spikes were added for PAH extractables analysis prior to extraction.

Extractables - anthracene - $^2H_{10}$

- benzo(a)pyrene - $^2H_{12}$

iv) Addition of phenanthrene - $^2H_{10}$ as the internal standard to sample extracts just prior to GC/MS analysis where GC/MS is involved.

v) Method blank performed to correct for laboratory contamination.

821-2705

Zenon Environmental Inc.
845 Harrington Court, Burlington, Ontario L7N 3P3 Tel.: (416) 639-6320 Telex: 061-8734 Fax: 639-1812

File No: AN388346

August 9, 1988

Bruce Wilson
GOLDER ASSOCIATES
1796 Courtwood Cres.,
Ottawa, Ontario
K2C 2B5

Dear Bruce:

Following our recent telephone conversation, I would like to address the matter of detection limits in the soil sample recently characterized for organic components (Reference ZENON report April 6th, 1988).

As mentioned in my letter of July 22nd, many of the compounds found in this sample were not available to us as pure standards and consequently their mass spectrometric responses have not been determined.

As a result of this, the determination of detection limits can only be done on an approximate basis. In reviewing the data from this sample an estimate of the detection limits would be approximately 1 ug/g.

If you have any questions or concerns please do not hesitate to contact me.

Yours truly,

M G Foster

M. Glenys Foster, Ph.D.
Manager
Analytical Services

MGF;sk

APPENDIX E

HEALTH AND SAFETY PROCEDURES

This appendix presents a brief description of the health and safety procedures in place during the investigation of the former manufactured gas plant site in Cornwall.

To protect the health and safety of personnel involved with site work, the following health and safety program was prepared by Golder Associates' health and safety officer and was based on Golder Associates corporate health and safety policy as well as relevent health and safety procedures for coal gasification plant sites developed by the Ontario Ministry of Labour (MOL).

The health and safety plan was reviewed and approved by MOL personnel.

During the drilling operations, all personnel on the site wore, as a minimum level of protection, the following:

- hard hat
- safety boots
- rubber overboots or safety toed rubber boots
- coated tyvek coveralls
- surgical gloves
- rubber gloves

During the drilling operations, air quality in the working zone was monitored on a continuous basis with a TIP II PID. If readings of greater than 10 ppm occurred on a consistent continuous basis, the personnel were instructed to wear half face air purifying respirators equipped with dusts and mists filters and organic vapor cartridges. During the drilling of borehole II-5 personnel were required to wear respirators from the start of drilling based on the presence of coal tar wastes in that area as determined during Phase I drilling.

On completion of the drilling activities all disposable safety equipment was placed in drums for off-site disposal.

To protect public health during the drilling operations, the parking lot was barricaded to prevent unauthorized access. In addition to restricting access, air quality monitoring was carried out at several stations around the site to monitor VOC concentrations in the air.

Prior to beginning the drilling of each borehole, heavy polyethylene sheeting was placed on the ground under the rear end of the drill to facilitate the clean up of cuttings. The cuttings and plastic sheeting were placed in disposal drums upon completion of each borehole.

The drums of cuttings and other wastes generated during the drilling were transported by licensed haulers to Stablex Ltee. in Blainville, Quebec for disposal in a licensed landfill.